

# Appendix I

## Agriculture, Forestry, and Waste Management Policy Recommendations

### Summary List of Policy Option Recommendations

	Policy Option	GHG Reductions (MMtCO <sub>2</sub> e)			Net Present Value 2007–2020 (Million \$)	Cost-Effective-ness (\$/tCO <sub>2</sub> e)	Level of Support
		2010	2020	Total 2007–2020			
AFW-1	Agricultural Soil Carbon Management – Conservation/No-Till	0.15	0.37	3.7	0	0	UC
	Agricultural Soil Carbon Management – Organic Farming	Not quantified					
AFW-2	Biodiesel Production (Incentives for Feedstocks and Production Plants)	0.02	0.15	0.9	13	14	UC
AFW-3	Ethanol Production	0.02	0.39	2.2	10	4	UC
AFW-4*	Incentives for Enhancing GHG Benefits of Conservation Provisions of Farm Bill Programs	0.5	1.6	15	181	12	UC
AFW-5	Preserve Open Space and Working Lands – Agriculture	0.003	0.02	0.12	5	32	UC
	Preserve Open Space and Working Lands – Forests	0.03	0.1	0.9	3	3	
AFW-6 <sup>†</sup>							
AFW-7 <sup>‡</sup>	Expanded Use of Biomass Feedstocks for Energy Use	0.04	0.15	1.1	–25	–23	UC
AFW-8	Afforestation/Reforestation Programs – Restocking	0.09	0.5	3.4	41	12	UC
	Afforestation/Reforestation Programs – Urban Trees	0.001	0.006	0.04	–0.1	–3	
AFW-9	Improved Management and Restoration of Existing Stands	0.05	0.2	1.3	159	119	UC
AFW-10	Expanded Use of Wood Products for Building Materials	Not quantified					UC
AFW-11	Programs to Promote Local Food and Fiber	0.01	0.02	0.12	0.5	5	UC
AFW-12	Enhanced Solid Waste Recovery and Recycling	0.05	0.55	3.3	58	17	UC
	Sector Total After Adjusting for Overlaps	0.44	2.4	17	446	26	
	Reductions From Recent Actions	0	0	0	0	0	
	Sector Total Plus Recent Actions	0.44	2.4	17	446	26	

GHG = greenhouse gas; MMtCO<sub>2</sub>e = million metric tons of carbon dioxide equivalents; UC = Unanimous consent.

\* The reductions for AFW-4 were not included in the total GHG reductions for this sector. These emissions relate to the protection of agricultural soil carbon and the potential emissions were not included in the GHG forecast for the agricultural sector.

† AFW-6 was folded into AFW-7 through AFW-9.

‡ For AFW-7, these reductions are associated with the use of additional woody biomass not consumed within the renewable energy options in the ES and RCII sectors.

## AFW-1. Agricultural Soil Carbon Management Programs – Conservation/No-Till and Organic Farming

### Policy Description

Use of conservation tillage/no-till and other soil management practices can increase the level of organic carbon in the soil, which sequesters carbon dioxide (CO<sub>2</sub>) from the atmosphere. In addition, some practices lower fossil fuel consumption through less intensive equipment use. Other practices, such as the application of bio-char can also increase the level of soil carbon and improve the soil. Organic farming methods may tend toward an increased use of these soil management practices. This option is designed to increase the acreage using soil management practices that lead to higher soil carbon content for both conventional and organic farming.

### Policy Design

**Goals:** Montana should adopt programs to increase the acres of cropland managed using best management practices, including conservation/no-tillage practices, by 50%. Currently there are approximately 18 million acres of cropland in Montana. Based on 2004 data, 3 million acres were in the Conservation Reserve Program (CRP), 7.9 million acres were in tillage, and the remaining 7.1 million acres were in summer fallow. A total of 5.5 million acres were in no-till (3.6 million acres were cropped and 1.9 million acres were in chemfallow). The acreage that could be used to sequester atmospheric carbon dioxide would be the remaining 9.5 million acres, including the 1.7 million acres currently managed by mulch-till practices that sequester a lesser fraction of carbon from the atmosphere.

An organic farming component is also included in this policy design recognizing that additional assessment and understanding of greenhouse gas (GHG) benefits is needed in the future. Compared to no-tillage systems, organic farming uses higher levels of tillage to manage weeds, to terminate cover crops and, in some cases, organic farming results in lower yields (leading to diminished GHG benefits). However, organic farming also does not use pesticides/herbicides and synthetic fertilizers and might achieve higher soil carbon levels than conservation tillage/no-till practices (leading to increased GHG benefits). Organic farming acreage is increasing at the following projected rates: 126,450 acres in 2005; 215,768 acres in 2010; 305,086 acres in 2015; and 394,404 acres in 2020. The initial goal will be to increase the organic acreage 15% above projected levels in 2015 and to 50% above 2025 levels for practices known to achieve net GHG benefits.

**Timing:** From 2007 to 2012 achieve a 20% increase in acres of cropland brought into no-till management practices, or an additional 1.1 million acres. By 2020, achieve a 50% increase in acreage for a total increase of 2.8 million acres in no-till/conservation tillage. This seems to be a reasonable goal considering that 1.7 million acres already in mulch-till practice could be brought into the no-till practices with incentives.

This policy also seeks an increase in organic farming acreage of 15% above the projected acreage in 2015 and 50% above the levels currently projected for 2025.

**Coverage of Parties:** Local Agricultural Extension offices, Montana Conservation District offices, United States Department of Agriculture–Natural Resources Conservation Service (USDA-NRCS) field offices, Montana Salinity Control Program, National Carbon Offset Coalition (NCOC), Montana Chapter of Soil and Water Conservation Society, Montana State University (MSU) Land Resource and Environmental Sciences (LRES) program, certified crop consultants, Montana Grain Growers Association.

**Other:** Policy goals for soil carbon sequestration on rangelands were not addressed by the Technical Work Group (TWG) under this policy option; however, additional information regarding opportunities for implementing GHG beneficial programs on rangelands is provided under Additional Benefits and Costs below.

### Implementation Mechanisms

**Conservation Security Program (CSP):** Federal funding of the CSP at levels specified in the 2002 Farm Bill would help provide incentives for participation in no-till and other conservation soil management strategies.

**Equipment Rebate Programs:** Economic incentives to transition to no-till practices might include a program that provides rebates for machinery traded in for no-till machinery (such as a 50% rebate), similar to automobile industry practices for replacing older low-gas mileage vehicles with new more fuel-efficient vehicles.

**Educational Outreach:** Change the perception of no-till practices among established farmers who a) continue to use historical cultivation practices, b) need technical and financial assistance to become comfortable with and to acquire the new technology needed, c) are concerned that insect control and plant disease management strategies may be impacted, and d) are wary of new practices that are not used by neighbors and that may negatively impact income from the farming enterprise.

**Other Incentives:** Improve the federal and state general cost-share programs to include no-till, removing some of the special area and conditions restrictions so it can fit under Environmental Quality Incentives Program (EQIP) and CSP.

### Related Policies/Programs in Place

**Conservation Reserve Program:** The CRP rewards farmers financially for removing highly erodible and marginally productive land from production. CRP is currently capped at 25% of Montana cropland per county.

Conservation Security Program (CSP).

Environmental Quality Incentives Program (EQIP).

Note: Both CSP and EQIP are relatively new programs designed to increase and provide cost-share for implementation of best management practices. These practices including, but not limited to, adoption of no-till farming practices.

Montana and USDA programs.

MSU Agriculture Research and Development programs.

### **Type(s) of GHG Reductions**

**CO<sub>2</sub>:** Reducing tillage and soil disturbance slows the breakdown of plant material on the soil surface and in the root zone, accelerating the microbial processes that stabilize carbon and protect carbon from oxidation, inhibiting the release of carbon back into the atmosphere. Depending on how the adoption of conservation tillage and organic production methods affects the overall crop production cycle, additional CO<sub>2</sub> reductions can occur through lower fossil fuel consumption in farm equipment. Note that some studies have shown higher fuel consumption using organic techniques than using conventional production techniques. Organic production methods also reduce GHG emissions associated with the production, transport, and application of pesticides, herbicides, and other chemical treatments.

**N<sub>2</sub>O:** To the extent that fossil fuel consumption is lowered through the cultivation methods implemented under this policy, nitrous oxide (N<sub>2</sub>O) emissions from fuel combustion will be lowered. It is important to note that research indicates the potential for higher N<sub>2</sub>O emissions as soil organic carbon levels increase.<sup>1</sup>

**CH<sub>4</sub>:** To the extent that fossil fuel consumption is lowered through the cultivation methods implemented under this policy, methane (CH<sub>4</sub>) emissions from fuel combustion will be lowered.

### **Estimated GHG Savings and Costs per MtCO<sub>2</sub>e**

**GHG Reduction Potential in 2010, 2020 million metric tons of carbon dioxide equivalents (MMtCO<sub>2</sub>e):** 0.15, 0.37.

*The reductions reported above and costs below only cover those associated with the conservation tillage/no-till elements of this policy option. The reductions to be achieved by the organic farming element could not be quantified with available information on the net GHG reduction potential of organic farming methods on Montana crop systems.*

**Net Cost per MtCO<sub>2</sub>e:** \$0.

### **Data Sources:**

#### *Conservation Tillage/No-Till*

Agricultural soil carbon accumulation levels are from a 2004 MontGuide Fact Sheet from the MSU Extension Service.<sup>2</sup> This report states that no-till practices result in an increase of soil carbon of 0.045 ton/acre over 10 years.

The reduction in fossil diesel fuel use from the adoption of conservation tillage methods is 3.5 gallons/acre.<sup>3</sup> From the Montana Inventory and Forecast, the fossil diesel GHG emission

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<sup>1</sup> Li et al., "Carbon Sequestration in Arable Soils Is Likely To Increase Nitrous Oxide Emissions, Offsetting Reductions in Climate Radiative Forcing," *Climate Change*, 72:321–338, 2005.

<sup>2</sup> P. Miller, R. Engel, and R. Brinklemeyer, *Soil Carbon Sequestration: Farm Management Practices Can Affect Greenhouse Gases*, MontGuide Fact Sheet #200404/Agriculture from the Montana State University Extension Service.

factor is 8.37 MtCO<sub>2</sub>e/1,000 gallons. Costs for adoption of conservation tillage/no-till practices are estimated to be \$0 based on averaging costs from two studies. The first study from North Carolina State University on applying these practices to cotton growing in North Carolina resulted in cost savings ranging from about \$3 to \$14 per acre per year.<sup>4</sup> The Center for Climate Strategies (CCS) used the low end of the range as a conservative estimate of cost savings. The second study from Iowa found that a subsidy of \$3 would be required to get non-adopters to switch to no-till.<sup>5</sup>

### *Organic Farming*

While organic farming practices are known to result in increases to soil organic carbon, the overall net GHG benefits are less certain. A new systematic study of organic farming methods in the United Kingdom<sup>6</sup> showed that with some agricultural systems, organic farming can produce net GHG benefits, while under others, GHG emissions were higher than in the analogous conventional system. The higher GHG emissions from organic systems in some cases are due to the need for additional mechanical cultivation since chemicals are not used (resulting in higher fossil fuel combustion). On the other hand, there is a reduction in chemical usage and the embedded fossil fuels used to produce and transport these products. There is also the potential, in some cases, for differing crop yields between organic and conventional systems (which leads to differing GHG emissions per ton of product).

Given these and other uncertainties, systematic studies are needed for Montana crop systems to determine where organic production methods can yield net GHG benefits. Once these systems are established, the policy calls for promoting those where net GHG benefits occur. This element of this policy proposal therefore remains unquantified.

## **Quantification Methods:**

### *Conservation Tillage/No-Till*

Based on the policy design parameters, the schedule for acres to be put into conservation tillage/no-till cultivation is shown in Table I-1. It was further assumed that the additional carbon would be sequestered in the soil over a period of 10 years (after 10 years, no further carbon is stored). The resulting annual carbon accumulation rate cited above was converted into its CO<sub>2</sub> equivalent yielding 0.15 MtCO<sub>2</sub>/acre/year.

To estimate carbon stored each year, the annual accumulation rate was multiplied by the number of acres in the policy program each year. After 10 years, the crop acres that entered the program were assumed to not store additional carbon. Results are shown in Table I-1.

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<sup>3</sup> Reduction associated with conservation tillage compared to conventional tillage, at <http://www.ctic.purdue.edu/Core4/CT/CRM/Benefits.html>, accessed August 2006.

<sup>4</sup> \$3–\$14/acre savings dependent on comparison of no-till to either strip till or conventional tillage. From “Economic Comparison of Three Cotton Tillage Systems in Three NC Regions,” S. Walton and G. Bullen, NCSU, at [www.ces.ncsu.edu/depts/agecon/Cotton\\_Econ/production/Economic\\_Comparison.ppt](http://www.ces.ncsu.edu/depts/agecon/Cotton_Econ/production/Economic_Comparison.ppt), accessed February 2007.

<sup>5</sup> “Costs and Environmental Effects From Conservation Tillage Adoption in Iowa,” Lyubov Kurkalova, Catherine Kling, and Jinhua Zhao.

<sup>6</sup> *Environmental Impacts of Food Production and Consumption*, Manchester Business School, prepared for the Department for Environment, Food and Rural Affairs, December 2006, [http://www.defra.gov.uk/science/project\\_data/DocumentLibrary/EV02007/EV02007\\_4601\\_FRP.pdf](http://www.defra.gov.uk/science/project_data/DocumentLibrary/EV02007/EV02007_4601_FRP.pdf)

Additional GHG savings from reduced fossil fuel consumption were estimated by multiplying the fossil diesel emission factor and diesel fuel reduction per acre estimate provided above. Results are shown in Table I-1 along with a total estimated benefit from both carbon sequestration and fossil fuel reductions.

**Table I-1. Schedule for acres to be put into conservation tillage/no-till cultivation**

Year	Acres in Program	Acres Still Accumulating Carbon	MMtCO <sub>2</sub> e Sequestered	Diesel Saved (1,000 gal)	MMtCO <sub>2</sub> e From Diesel Avoided	Total MMtCO <sub>2</sub> e Saved
2006	0	0	0.00	0	0.00	0.00
2007	0	0	0.00	0	0.00	0.00
2008	275,000	275,000	0.04	963	0.01	0.05
2009	504,167	504,167	0.08	1,765	0.01	0.09
2010	825,000	825,000	0.12	2,888	0.02	0.15
2011	1,054,167	1,054,167	0.16	3,690	0.03	0.19
2012	1,283,333	1,283,333	0.19	4,492	0.04	0.23
2013	1,512,500	1,512,500	0.23	5,294	0.04	0.27
2014	1,741,667	1,741,667	0.26	6,096	0.05	0.31
2015	1,970,833	1,970,833	0.30	6,898	0.06	0.35
2016	2,200,000	2,200,000	0.33	7,700	0.06	0.39
2017	2,429,167	2,429,167	0.36	8,502	0.07	0.43
2018	2,658,333	2,383,333	0.36	9,304	0.08	0.43
2019	2,887,500	2,383,333	0.36	10,106	0.08	0.44
2020	2,750,000	1,925,000	0.29	9,625	0.08	0.37

### Key Assumptions:

The assumed carbon sequestration potential is representative across all of the crop systems to which the policy is applied; a 10-year period for accumulating the soil carbon; no additional significant accumulation of soil carbon after 10 years; any potential increase in N<sub>2</sub>O emissions is not large enough to significantly affect the estimated benefits; cost savings is a representative average of savings to be achieved across all crop systems.

### Key Uncertainties

Most of the conservation tillage considered business as usual (BAU) in this analysis is being done for soil conservation instead of carbon sequestration. These acres may be tilled periodically, since doing so does not significantly harm the soil conservation goal. Only an estimated 15% of the conservation tillage reported is continuous. However, periodic tilling can have a significant negative effect on the carbon sequestration goal, as the emissions in one tilling cycle can destroy several years' worth of no-till carbon sequestration. Incentives to early adopters of conservation tillage may be required to prevent periodic tillage and the resulting soil carbon losses.

### Additional Benefits and Costs

These include reduced emissions of criteria and toxic air pollutants from fossil fuel combustion.

No attempt has been made to quantify the potential for carbon sequestration on rangeland in Montana. This brief explanation of the opportunity for rangeland sequestration and the management practices required to obtain the desired sequestration is meant to identify the benefits of such practices and to ensure the recognition of rangeland management to reducing GHGs in any proposed Montana state GHG mitigation initiatives.<sup>7</sup>

The USDA NRCS defines rangeland as “Land on which the historic plant community is principally native grasses, grass-like plants, forbs or shrubs suitable for grazing and browsing. In most cases, range supports native vegetation that is extensively managed through the control of livestock rather than by agronomy practices, such as fertilization, mowing, or irrigation. Rangeland also includes areas that have been seeded to introduced species (e.g., clover or crested wheatgrass) but are managed with the same methods as native range.”

Rangeland management practices that increase carbon sequestration in rangeland soils include the following tools:

- Light or moderate stocking rates, and
- Sustainable livestock distribution, which includes rotational grazing and seasonal use.

In Montana, the soil sequestration rates currently established for sustainable grazing systems range from 0.12 MtCO<sub>2</sub>/acre to 0.40 MtCO<sub>2</sub>/acre. The sequestration rate depends on the determination of whether the range is in a non-degraded or degraded condition. The NRCS has established indicators of degraded rangeland that are published in the 2005 “Interpreting Indicators of Rangeland Health.” NRCS Field Office Technical Guides provide guidelines for managing the controlled harvest of vegetation with grazing animals. Stocking rates and livestock distribution criteria are defined according to county and state in the NRCS “Prescribed Grazing Specification” code.

## **Feasibility Issues**

Because of the high amount of intermittent or periodic no-till cultivation being implemented in the state, the BAU for Montana cropland is any tillage based soil management or conservation tillage system that has been adopted for soil conservation or fuel reduction purposes but not for generating carbon sequestration or offset credits (i.e., including intermittent no-till cultivation). With this understanding of BAU, farmers who adopt continuous no-till practices could be eligible to take part in carbon crediting programs (e.g., Chicago Climate Exchange).

The following are reasons for this definition:

- Currently there are no governmental requirements for continuous no-till (i.e., direct seed) cropping for carbon sequestration. A significant amount of the existing no-till acreage in Montana is therefore potentially subjected to periodic tillage for weed management or seeding with wide-shovel furrow openers. Where this is the case, the soil conservation effects of the practice are maintained, but much if not most of the carbon sequestration impact is lost.

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<sup>7</sup> Information on rangelands provided by T. Dodge, AFW TWG, to S. Roe, CCS, May 2007.

- Moving producers from intermittent tillage to continuous no-till direct seed cropping provides a carbon benefit while at the same time reducing the flexibility to do intermittent tillage, and it may require producers to use different equipment.

Accommodations for early adopters are also needed.

The small percentage of cropland in Montana that is in continuous no-till direct seed cropping will continue to provide CO<sub>2</sub> reductions for 10 to 15 additional years, depending on adoption year. Not allowing these operators to begin to receive credit for their management is to penalize early action when it is in the best interest of the State of Montana to give credit for early action and encourage voluntary reductions for CO<sub>2</sub>.

### **Status of Group Approval**

Completed.

### **Level of Group Support**

Unanimous consent.

### **Barriers to Consensus**

None.

## AFW-2. Biodiesel Production (Incentives for Feedstocks and Production Plants)

### Policy Description

The use of biodiesel offsets the consumption of diesel fuel produced from oil (fossil diesel). Since biodiesel has a lower GHG content than fossil diesel (being derived from biogenic sources), overall GHG emissions are reduced. By producing biodiesel in the state for consumption within the state, the highest benefits can be achieved, since the fuel is transported over shorter distances to the end user (as compared with importing biodiesel to Montana from other states). This option covers incentives needed to increase biodiesel production in Montana.

*Note that this policy option is linked with the low-carbon fuels policy in the Transportation and Land Use (TLU) sector. That policy option seeks to achieve greater consumption of lower carbon fuels in the state, while this option seeks to promote lower carbon fuel production in the state (to help meet future demand).*

### Policy Design

**Goals:** Produce sufficient biodiesel from Montana feedstocks to meet 2%, 10%, and 20% of 2004 Montana petroleum diesel consumption by 2010, 2015, and 2020, respectively.

**Timing:** See above.

**Parties Involved:** Montana Department of Environmental Quality (MDEQ), Montana Department of Agriculture (MDOA), Montana Farmers Union, Resource Conservation and Development, Montana Grain Growers, MSU, Montana Livestock Associations.

**Other:** According to the Montana Department of Transportation (MDT), the 2004 petroleum diesel consumption in Montana was 372 million gallons (MG). Of this total, 220 MG were used by on-road vehicles and 152 MG were used for off-road equipment (primarily in construction, mining, and locomotive use). Production targets would be 7 million gallons/year (MGY) in 2010, 37 MGY in 2015, and 74 MGY in 2020.

### Implementation Mechanisms

**Financial Incentives:** Financial assistance (e.g., tax breaks, grants, and payments) for oilseed producers.

- Extend the biodiesel production incentive when it expires in 2010.
- Provide payments to growers in the amount of the difference between the highest incomes they could otherwise receive from oil seeds and the cost of growing oil seeds. Examples of the highest income that could be received include the cost of growing oil seeds for human food or the cost of leaving land in CRP.

**Research and Development:** Research and development of oil-bearing feedstocks (e.g., oilseeds, algae) and production processes for co-products and agricultural uses.

**Information and Outreach:** Education programs for

- Livestock producers to utilize feed co-products;
- Growers of oil seeds and other feedstocks and professionals who provide technical assistance to these groups;
- Consumers to link demand-side mechanisms under TLU Policy Option 6 (TLU-6) to the benefits associated with fuels produced in-state (e.g., fossil fuel dependence and benefits for in-state agriculture); and
- Industry to increase awareness of biodiesel incentives, including the availability of tax incentives to producers, oil seed crushers, distributors, retailers, and consumers.

**Business Development:** Recruit biodiesel producers to locate facilities in Montana.

**Intergovernmental Coordination:** Create an interagency work group to coordinate efforts at the MDOA, MDEQ, Montana Department of Commerce, Montana Department of Labor and Industry, MDT, the Governor's Office of Economic Development, and universities to identify barriers to biodiesel production and use in Montana.

**Coordinated Permitting of Facilities:** Separate permits are potentially required for air quality, water quality, and waste management at biodiesel production facilities. MDEQ should establish internal procedures to allow for coordinated permitting guidelines from all parts of the department and, when necessary, to convey requirements of other agencies such as the MDT.

**Biodiesel Testing Facility:** Establish an in-state facility to test biodiesel to ensure that the American Society for Testing and Materials (ASTM) standards are met by new companies starting biodiesel production and as companies grow.

**State Lead by Example:** Establish a biodiesel fueling system and use biodiesel in the state government fleet. Include requirements for state-hired contractors to use biodiesel.

### **Related Policies/Programs in Place**

**Biodiesel Production Incentive:** This is a 10-cent-per-gallon tax biodiesel production incentive. For the first year of production, the incentive is for the total gallons produced, and then the incentive is for the additional gallons produced over and above the previous year for up to 3 years. This incentive is paid from the state general fund to produce, refine, or manufacture biodiesel for sale, use, or distribution (15-70-601 Montana Code Annotated [MCA]) and terminates in 2010.

**Tax Credit for Investment in Oil Seed Crush Facility:** This is a tax credit of 15% of the cost of depreciable equipment invested in property to crush oil seeds for up to \$500,000. The credit may be carried forward for up to 7 years (15-32-701 MCA and 2007 Legislature House Bill [HB] 166).

**Tax Credit for Investment in Biodiesel Production Facility:** This is a tax credit of 15% of the cost for construction and equipment in a facility that produces biodiesel. The tax can be carried forward for up to 7 years (15-32-701 MCA and 2007 Legislature HB 166).

**Tax Credit for the Storage and Blending of Biodiesel:** This is a tax credit of 15% of the cost of equipment needed to store and blend biodiesel. A distributor can claim up to \$52,500 and a motor fuel outlet can claim up to \$7,000 (15-32-703 MCA and 2007 Legislature HB 166).

**Refund for Biodiesel Taxes Paid:** A licensed distributor may claim a refund of 2 cents per gallon for biodiesel sold when the biodiesel is made from Montana products, and retailers can claim 1 cent per gallon sold (15-70-369 MCA).

**Property Tax Abatement:** The May 2007 Special Session of the Montana Legislature passed a comprehensive tax abatement bill for the development of clean energy in Montana. Biodiesel production and research and demonstration facilities would receive an abatement of property taxes (May 2007 Legislature Special Session HB 3).

**Training for Students and Professionals:** Montana has received a federal Work Force Innovation and Rural Economic Development (WIRED) grant to assist with the development of biodiesel and ethanol by training students at Montana schools and by educating professionals who will work with biodiesel, thus building the human capital for future GHG reductions through biodiesel production.

**CO<sub>2</sub>:** Life cycle emissions are reduced to the extent that biodiesel is produced with lower embedded fossil-based carbon than conventional (i.e., fossil) diesel fuel. Feedstocks used for producing biodiesel can be made from crops or other biomass, which contain carbon sequestered during photosynthesis (e.g., biogenic or short-term carbon). The primary feedstocks for biodiesel are oils derived from oilseed crops (e.g., soybeans, canola, sunflower camelina, or algal) and alcohols (either methanol or ethanol). From a recent report (Hill et al., 2006),<sup>8</sup> biodiesel from soybeans contains 93% more usable energy than its petroleum equivalent and reduces life cycle GHG emissions by as much as 41%. Higher oil production potential of different feedstocks (e.g., other oil crops, algae) will likely adjust the life cycle GHG emissions further downward as they are developed as biodiesel sources. Local production of biodiesel also decreases the embedded CO<sub>2</sub>e of biodiesel compared with importation of out-of-state vegetable oil supplies.

#### **Estimated GHG Savings and Costs per MtCO<sub>2</sub>e**

**GHG Reduction Potential in 2010, 2020 (MMtCO<sub>2</sub>e):** 0.02, 0.15.

*Note: these estimated reductions are incremental to those estimated for low carbon fuels standard under TLU-6 (assumes that lower carbon diesel fuel demand is met primarily through soybean-based biodiesel).*

**Net Cost per MtCO<sub>2</sub>e:** \$14.

**Data Sources:** The CO<sub>2</sub>e emission factor for fossil diesel combustion used in the Inventory and Forecast is 10.04 Mt/1,000 gallons. The life cycle fossil diesel emission factor is 12.3 Mt/1,000 gallons.<sup>8</sup> The life cycle emission factor includes the emissions from combustion plus the

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<sup>8</sup> Hill et al., 2006, "Environmental, economic, and energetic costs and benefits of biodiesel and ethanol biofuels," *Proceedings of the National Academy of Sciences*, 103:11206–11210, July 25, 2006.

emissions associated with petroleum extraction, processing, and distribution. Information on potential production of crop oil feedstocks in Montana was provided by MDOA.

## **Quantification Methods:**

### *GHG Reductions*

A new study on life cycle GHG benefits for biodiesel production and use was used to estimate the CO<sub>2</sub>e reductions for this option.<sup>9</sup> This study covered biodiesel production from soybean production, which is currently the predominant feedstock source for biodiesel production in the United States and is assumed to remain that way for the purposes of this analysis. Life cycle CO<sub>2</sub>e reductions (via displacement of fossil diesel with soybean-derived biodiesel) were estimated by Hill et al. to be 41%. This value is being used to estimate the benefit of the biodiesel component of the TLU biofuels option. Hence, this analysis focuses on incremental benefits of in-state feedstocks (i.e., oil) production with the focus on vegetable oils that produce greater volumes of oil per unit of energy input (e.g., canola).

As a result of biodiesel processing, each gallon of vegetable oil will produce slightly less than one gallon of biodiesel. However, for the purposes of this analysis, each gallon is assumed to produce one gallon of biodiesel.

Feedstocks included in this analysis are canola, camelina, sunflower, mustard, and safflower oil. For oil sources other than soybean oil, the benefit for substituting in-state biodiesel for fossil diesel is estimated starting with the life cycle soybean emission factor (7,261 MtCO<sub>2</sub>e/million gallons [MMgal] from the Hill et al. study).

As shown in Table I-2, by 2020, MDOA estimates that canola can produce 80 gallons of oil per acre compared with soybeans, which produce 46 gallons/acre. Assuming canola production energy inputs are not significantly greater than soy, the life cycle emission rate for canola would be  $7,261 \times 46/80$  or 4,175 MtCO<sub>2</sub>e/MMgal. Therefore, the incremental benefit of canola over soy is  $7,261 - 4,175 = 3,086$  MtCO<sub>2</sub>e/MMgal. The other crops shown in Table I-2 also produce greater volumes of oil per acre than soy, except for mustard. Hence, the incremental GHG benefit for obtaining feedstock from mustard versus soy is zero.

The mix of oil feedstocks assumed in this analysis is shown in Table I-2.<sup>10</sup> Biodiesel gallons per acre were derived for 2010 based on 8-year oilseed yields and currently available oil extraction technologies. The 2015 gallon amounts were largely increased by assuming that more efficient extraction and processing technologies will be readily available at that time. The 2020 amounts assumed increases in yield and oil content based on the annual millions of dollars in agronomic research investment as illustrated by more than 20 years of work with safflower.

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<sup>9</sup> Ibid.

<sup>10</sup> Crop share estimates provided by Howard Haines, Montana DEQ.

**Table I-2. Estimated seed oil feedstock production and acreage needs**

<b>Crop</b>	<b>Crop Share, %</b>	<b>Gallons of Oil per Acre</b>	<b>Biodiesel (MGY)</b>	<b>Estimated Acres (1,000)</b>
<b>2010</b>				
Canola	29.0	58	2.2	37
Camelina	48.0	32	3.5	111
Mustard	12.0	30	0.9	29
Safflower	11.0	40	0.8	20
Sunflower	0	41	0.0	0
<b>Total</b>	<b>100.0</b>		<b>7.4</b>	<b>197</b>
<b>2015</b>				
Canola	25.0	64	9.2	145
Camelina	40.0	60	14.8	244
Mustard	13.9	32	5.2	161
Safflower	20.0	44	7.4	168
Sunflower	1.1	51	0.4	8
<b>Total</b>	<b>100.0</b>		<b>37</b>	<b>726</b>
<b>2020</b>				
Canola	30.0	80	22.2	278
Camelina	42.0	70	31.2	446
Mustard	24.0	42	17.8	425
Safflower	3.5	55	2.5	47
Sunflower	0.5	64	0.3	6
<b>Total</b>	<b>100.0</b>		<b>74</b>	<b>1,202</b>

GHG reductions were estimated by multiplying the production of each oil feedstock by the applicable incremental energy-related benefit (e.g., by oil type). Total reductions in each year were estimated by summing the incremental benefit for each oil type (i.e., incremental benefit over soy).

### *Costs*

Costs were estimated using information from an analysis of biodiesel production costs from the United States Department of Energy (US DOE).<sup>11</sup> Costs of this option are assumed to be equal to the value of incentives needed to encourage meeting the biodiesel production targets. The value of those incentives is assumed to be equivalent to the difference in the costs of producing fossil diesel and soy-based biodiesel (\$0.34/gallon). This value is very close to the incentive offered in a State of Missouri incentives program.<sup>12</sup> This program offers production incentives of \$0.30/gallon to producers of up to 15 MGY. The incentive grants last for 5 years. This analysis assumed a similar incentive structure in Montana, and that these would cover the costs of all grants or tax incentives associated with this policy (all other implementation mechanisms are assumed to be achieved within existing programs). The cost estimates for this option are based therefore on multiplying the amount of biodiesel produced

<sup>11</sup> See [www.eia.doe.gov/oiaf/analysispaper/biodiesel/index.html](http://www.eia.doe.gov/oiaf/analysispaper/biodiesel/index.html), accessed January 2007.

<sup>12</sup> Information on the Missouri Program: [www.newrules.org/agri/mobiofuels.html#biodiesel](http://www.newrules.org/agri/mobiofuels.html#biodiesel), accessed January 2007.

in each year by the production incentive. This assumes that all production occurs at production facilities of less than 15 MGY. The production incentive runs out after 5 years of production. The existing \$0.10/gallon incentive in Montana was factored into the cost-effectiveness estimate. Information on the value of the other biodiesel production incentives was not readily available to factor into this analysis.

Table I-3 summarizes the calculation of the levelized and discounted cost-effectiveness calculated for this policy option, given the incentive payment and the production schedule above. It is calculated by dividing the total discounted costs of the policy option (5% discount rate applied) by the total metric tons of CO<sub>2</sub>e reduced by the option. Incentive costs are only incurred for the first 5 years (as mentioned above).

**Table I-3. Calculation of discounted and levelized cost-effectiveness**

Year	Capacity Needed (1,000 gallons)	Incentive Costs	Discounted Cost	Avoided Emissions (MMtCO <sub>2</sub> e)	Cost-Effectiveness	Levelized / Discounted CE
2007	0	\$0	\$0	0.00		
2008	2,480	\$595,200	\$595,200	0.01	\$108	
2009	4,960	\$1,190,400	\$1,133,714	0.01	\$103	
2010	7,440	\$1,785,600	\$1,619,592	0.02	\$98	
2011	13,392	\$4,553,280	\$3,933,294	0.03	\$139	
2012	19,344	\$6,576,960	\$5,410,881	0.04	\$135	
2013	25,296	\$0	\$0	0.05	—	
2014	31,248	\$0	\$0	0.06	—	
2015	37,200	\$0	\$0	0.08	—	
2016	44,640	\$0	\$0	0.09	—	
2017	52,080	\$0	\$0	0.11	—	
2018	59,520	\$0	\$0	0.12	—	
2019	66,960	\$0	\$0	0.14	—	
2020	74,400	\$0	\$0	0.15	—	
			<b>\$12,692,682</b>	<b>0.89</b>		<b>\$14</b>

**Key Assumptions:** Life cycle GHG emission factors utilized/derived for this analysis are representative of each feedstock and for fossil diesel. Production incentives offered by this option are sufficient to drive production of GHG-superior feedstocks (i.e., superior to soybeans) and to increase the level of research and development needed for non-crop based feedstocks (e.g., algal biodiesel, Fischer-Tropsch biodiesel).

The inputs into canola and camelina are assumed to be equivalent to soy for this analysis. Soy fixes nitrogen so requires little fertilizer, which may affect the comparison.

## Key Uncertainties

**Availability of crop acreage to devote to vegetable oil production:** the analysis showed a need for 1.2 million acres devoted to vegetable oil production by 2020. There is also the potential for unforeseen impacts on existing animal feed and food crop systems with the level of vegetable oil crop acreage analyzed here. The potential for these impacts, as well as potential impacts to Montana agricultural exports needs further analysis. As mentioned above, the introduction of new and more efficient feedstock sources would lower the amount of acreage required. GHG emissions associated with higher levels of vegetable oil production are assumed to be adequately captured within the life cycle emission factors from recent studies (as described in the Quantification Methods section above).

Oilseed acreage projections do not account for variables in market demand. Global market forces will determine Montana farmers' crop planting decisions, as well as the end-uses of harvested crops. Even if projected oilseed acreages are realized, it is possible that harvested crops will be used for purposes other than biodiesel production.

## Additional Benefits and Costs

Increased in-state economic activity, oilseeds as rotational crop, reduced herbicide/pesticide and fertilizer use on traditional crops; increased transportation energy security with shorter transport distances and on-farm use of fuel produced; reduced reliance on imported petroleum.

## Feasibility Issues

Sourcing of feedstocks and the size and location of facilities (both crushing and biodiesel production) must be addressed for optimization and planning. Canola may be one of the crops with higher value markets than for biodiesel. Canola oil has very favorable nutritional and culinary qualities. As demand for trans fat-free vegetable oils increases, demand for canola oil and other healthy oils grown in Montana will increase.

There will be interaction with potential ethanol production crops and carbon sequestration, although expanded use of biodiesel will continue to replace/reduce GHG emissions beyond the ability of the land to sequester carbon. There may be an overlap among agricultural options (especially AFW-1 through AFW-4) that should be carefully considered. For example, AFW-1 and AFW-4 seek to increase/maintain crop acreage in no-till production or in conservation management programs. This could be in conflict with the higher levels of crop production proposed in this option.

Some of the crops identified for biodiesel production may have higher value as a food crop. This would limit the amount that could be grown for biodiesel. Camelina is showing promise for oil seed production but has not yet been grown in large quantities, and the long-term results are uncertain.

Global warming may also impact the results since goals in AFW-2 depend on cold climate oilseed production in Montana. Additional warming could favor warmer climate crops such as sunflower and safflower to replace the cold climate crops, but these crops need more water, which may not be available.

**Status of Group Approval**

Completed.

**Level of Group Support**

Unanimous consent.

**Barriers to Consensus**

None.

## AFW-3. Ethanol Production

### Policy Description

Offset fossil fuel use (e.g., gasoline) with production and use of starch-based and cellulosic ethanol. Offsetting gasoline use with ethanol can reduce GHGs to the extent that the ethanol is produced with lower GHG content than gasoline. Provide incentives for the production of ethanol from crops, forest sources, animal waste, and municipal solid waste (MSW). Also encourage cellulosic ethanol production research and development already initiated by the MDOA.

*Note that this policy option is linked with the low-carbon fuels policy in the Transportation and Land Use sector. That policy option seeks to achieve greater consumption of lower carbon fuels in the state, while this option seeks to promote lower carbon fuel production in the state (to help meet future demand).*

### Policy Design

**Goals:** By 2010, achieve in-state production levels of 50 MGY of starch-based ethanol and 2 MGY of cellulosic production; by 2015, achieve in-state production levels of 110 MGY of starch-based ethanol and 25 MGY of cellulosic production; by 2020, achieve in-state production levels of 250 MGY of starch-based ethanol and 50 MGY of cellulosic production.

**Timing:** See above.

**Parties Involved:** MDEQ, MDOA, Montana Farmers Union, Montana Association of Ethanol Producers, Farm Bureau, conservation districts, Montana Extension Service, Montana Stock Growers and Wool Growers Associations, Montana Grain Growers Association and Montana Co-Op Development Center, farmers, Montana Department of Natural Resources and Conservation (DNRC), U.S. Forest Service (USFS), Bureau of Land Management (BLM), MSU Cooperative Extension, University of Montana College of Forestry and Conservation, and the forest products industry.

**Other:** None.

### Implementation Mechanisms

**Pilots and Demonstrations:** Pilot projects on the use of different forestry and agriculture residues for ethanol production are needed.

**Tax Incentives:** Provide incentives to reduce the capital costs of ethanol production and transport. Gross receipts exemptions for ethanol production facilities, project construction, and related equipment and materials are also recommended.

**Source Reduction:** Reduce the amount of open slash pile burning on all land ownerships and/or provide viable alternatives to open burning. Discourage open burning through alternatives to burning provided under the best available control technologies as defined in the Administrative

Rules of Montana, through revised MDEQ air quality permits when permits are needed, and by using local programs to encourage alternatives to burning.

**Financial Assistance:** Tax breaks or grants for ethanol producers.

**Research and Development:** Focusing on feedstock supplies (biomass from agricultural residues, MSW, and forestry residue) and production processes (cellulosic processes or starch-based processes achieving similar net GHG benefits).

**Information and Education:** For target audiences.

- Education programs for livestock producers to utilize feed co-products.
- Education programs for feedstock producers.
- Consumer education programs to link demand-side mechanisms under TLU-6 to the benefits associated with fuels produced in-state (e.g., fossil fuel dependence, benefits for in-state agriculture).

**Permitting Process:** Streamlined permitting process with coordination between all entities issuing permits for land, water, and air impacts for production facilities.

**Business Development:** Recruitment of cellulosic/advanced starch-based ethanol producers to locate facilities in Montana.

### **Related Policies/Programs in Place**

The major sections of Montana's laws for ethanol are mostly tax-related and are listed in sections of the MCA.

**Tax Credit for Ethanol Production 15-70-522 MCA:** This is a tax incentive for the production of alcohol to be blended for gasohol; other laws provide for the proper administration and enforcement of the tax incentive. The incentive on each gallon of alcohol is 20 cents for each gallon that is 100% produced from Montana products to an ethanol producing facility.

**Tax Credit for Ethanol Blended Fuels 5-70-204 MCA:** This states that gasohol is subject to 85% of the tax imposed in subsection (1)(b), which is 27 cents for each gallon of all other gasoline distributed by the distributor within the state.

**Consumer Credit 15-70-221 MCA:** This incentive states that a person who purchases and uses any gasoline on which the Montana gasoline license tax has been paid for denatured alcohol to be used in gasohol is eligible for a refund or credit on the gasoline license tax.

**Construction Incentive 15-6-220 MCA:** This provides that all manufacturing machinery, fixtures, equipment, and tools used for the production of ethanol from grain during the course of the construction of an ethanol manufacturing facility and for 10 years after completion of construction of the manufacturing facility is exempt from property taxation.

**Motor Vehicle Conversion Incentive 15-30-164 MCA:** This provides a tax credit against taxes for equipment and labor costs incurred to convert a motor vehicle licensed in Montana to operate

on alternative fuel. For the purposes of this section, “alternative fuel” includes fuel that is at least 85% methanol, ethanol or other alcohol, ether, or any combination of them.

**State Government use of Ethanol 2-17-414 MCA:** This states that state government and a state institution of higher education owning or operating a motor vehicle capable of burning ethanol-blended fuel shall take all reasonable steps to ensure that the operators of those vehicles use ethanol-blended fuel (90% gasoline and 10% anhydrous ethanol produced from agricultural products) in the vehicles.

**Property Tax Abatement:** The May 2007 Special Session of the Montana Legislature passed a comprehensive tax abatement bill for the development of clean energy in Montana. Property tax rate abatement reductions (non-permanent incentives) range from 1.53% to 31.5% and are available for new investments in biodiesel, biomass, biogas, cellulosic ethanol, carbon sequestration equipment, renewable energy manufacturing plants, and research and development equipment for clean coal or renewable energy.

**USFS, Northern Region Woody Biomass Utilization Policy:** Recently implemented, this policy requires that contractors doing work on federal lands, haul and pile slash at landings to help facilitate removal of biomass during forest operations for utilization.

**State Trust Lands Forest Management Program:** Recently implemented, the Forest Management Bureau has changed the timber bid sale process for state trust lands to incentivize removal of residues for pulp and biomass by giving priority consideration to bids that include biomass removal.

### Type(s) of GHG Reductions

**CO<sub>2</sub>:** Life cycle emissions are reduced to the extent that ethanol is produced with lower embedded fossil-based carbon than conventional (i.e., fossil) fuel. Feedstocks used for producing ethanol can be made from crops or other biomass that contains carbon sequestered during photosynthesis (e.g., biogenic or short-term carbon). There are two different methods for producing ethanol based on two different feedstocks. Starch-based ethanol is derived from corn or other starch/sugar crops. Cellulosic ethanol is made from the cellulose contained in a wide variety of biomass feedstocks, including agricultural residue (e.g., wheat and barley straw), forestry waste, purpose grown crops (e.g., sweet sorghum, switchgrass), and MSW. Local production of ethanol also decreases the embedded CO<sub>2e</sub> of ethanol compared with importation from the current U.S. primary ethanol producing regions. Current research indicates that cellulose-based ethanol production provides a reduction in GHGs of up to 72%–85% compared to gasoline, whereas an 18%–29% reduction is measured from starch-based ethanol production compared with gasoline.

### Estimated GHG Savings and Costs per MtCO<sub>2e</sub>

**GHG Reduction Potential in 2010, 2020 (MMtCO<sub>2e</sub>):** 0.02, 0.39.

*Note: these estimated reductions are incremental to those estimated for low carbon fuels standard under TLU-6 (only reflects the benefit associated with in-state cellulosic ethanol, since it is assumed that the low-carbon gasoline demand under TLU-6 is met primarily through starch-based ethanol. Although some benefit would be achieved by producing starch-based ethanol in-*

*state versus transporting it from out of state, these incremental benefits are estimated to be minimal).*

**Net Cost per MtCO<sub>2</sub>e: \$4.**

*Note: As with the benefits above, the costs are those associated with incentives for cellulosic ethanol feedstocks and production methods.*

**Data Sources:** The computation of the GHG reduction potential and cost-effectiveness of this option is based upon the following data:

Emission factors for gasoline and ethanol (both starch-based and cellulosic) were taken from a General Motors/Argonne National Laboratory Study.

Research completed by the Energy Information Administration (EIA) provided the cost of production for starch-based and cellulosic ethanol.

**Quantification Methods:**

*GHG Reductions*

The benefits for this option are dependent on developing in-state production capacity that achieves benefits above the levels of existing and planned (BAU) starch-based production in the United States. In this analysis, this analysis estimates the incremental benefit of the policy option to that achieved via implementation of TLU-6, which promotes consumption of low-carbon fuels. The primary assumption in this analysis is that the reductions in carbon content of gasoline within the policy period achieved through implementation of TLU-6 will be met primarily through higher consumption of starch-based ethanol. Hence, the benefit for this option is driven by the production of fuels in-state that have lower embedded GHG than starch-based ethanol (e.g., cellulosic ethanol).

Emission factors for reformulated gasoline, starch-based ethanol, and cellulosic ethanol were taken from a General Motors/Argonne National Laboratory study.<sup>13</sup> These emission factors incorporate the GHG emissions during the entire life cycle of fuel production (e.g., for gasoline: extraction, transport, refining, distribution, and consumption; for ethanol: crop production, feedstock transport, processing, distribution, and consumption). These life cycle emission factors are referred to as “well-to-wheels” emission factors:

- Reformulated gasoline: 552 grams CO<sub>2</sub>e/mi
- Starch-based ethanol: 451 grams CO<sub>2</sub>e/mi
- Cellulosic ethanol: 154 grams CO<sub>2</sub>e/mi

Based on the emission factors shown above, the incremental benefit of the production targeted by this policy over conventional starch-based ethanol is 66% (reduction of CO<sub>2</sub>e by offsetting gasoline consumption). This value was used along with the life cycle emission factor for

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<sup>13</sup> “Well-to-Wheels Analysis of Advanced Fuel/Vehicle Systems—A North American Study of Energy Use, Greenhouse Gas Emissions, and Criteria Pollutant Emissions,” General Motors, Argonne National Laboratory, and Air Improvement Resource, Inc., May 2005.

gasoline<sup>14</sup> and the production in each year to estimate GHG reductions. Table I-4 gives the amount of cellulosic ethanol and feedstock needed for each year.

**Table I-4. Amount of cellulosic ethanol (EtOH) and feedstock for years 2008–2020**

Year	MMGal EtOH Capacity Needed	Cellulosic Feedstock Needed (dry tons)
2008	0.7	9,524
2009	1.3	19,048
2010	2.0	28,571
2011	6.6	94,286
2012	11.2	124,444
2013	15.8	175,556
2014	20.4	226,667
2015	25.0	277,778
2016	30.0	333,333
2017	35.0	388,889
2018	40.0	444,444
2019	45.0	500,000
2020	50.0	500,000

### *Costs*

Costs for the incentives needed by this policy option are based on the difference in estimated production costs between conventional starch-based ethanol and cellulosic ethanol. The US DOE EIA estimated that the cost to produce starch-based ethanol is \$1.10/gal compared to \$1.29/gal, or a difference of \$0.19/gal (in \$1998).<sup>15</sup> In 2006 dollars, the difference is \$0.23/gal. These incentives are considered necessary in the near term (up to 2015) to help commercialize technologies that produce ethanol from cellulose or produce starch-based ethanol using renewable fuels. The incentives should also help establish the infrastructure to deliver biomass to bio-refineries, since producers will seek the local feedstocks or renewable fuels for their operations.

By 2015, it is assumed that advances in cellulosic ethanol production (e.g., enzyme costs, production processes) will make cellulosic ethanol production cost competitive with starch-based production. Hence, the incentives are discontinued beginning in 2015. Note that there is currently a federal legislative proposal to offer cellulosic production an incentive of \$0.765/gal compared with the \$0.51/gal currently offered for ethanol production.<sup>16</sup> If enacted, this \$0.255/gal premium could cover the additional incentives that are assumed to be needed by the State of Montana. Obviously, the federal incentives do not ensure that production facilities would locate in Montana. These federal incentives have not been factored into the cost estimates for this option.

<sup>14</sup> In the study mentioned above, the average fuel economy used was 21.3 miles/gallon or 100 miles/4.7 gallons. Multiplying this value by the emission factor of 552 grams/mile yields 11,745 grams/gallon.

<sup>15</sup> DOE EIA analysis can be found at [www.eia.doe.gov/oiaf/analysispaper/biomass.html](http://www.eia.doe.gov/oiaf/analysispaper/biomass.html), accessed January 2007.

<sup>16</sup> D. Morris, *Making Cellulosic Ethanol Happen: Good and Not So Good Public Policy*, Institute for Local Self-Reliance, January 2007, at [www.newrules.org/agri/cellulosicethanol.pdf](http://www.newrules.org/agri/cellulosicethanol.pdf), accessed January 2007.

The costs for this option were estimated using the \$0.23/gal incentive multiplied by the production needed in each year. By 2015, it is assumed that these incentives will no longer be needed as cellulosic ethanol technologies become fully commercialized. Hence, the costs for this option are targeted toward incentives for cellulosic ethanol production (including research and development, pilot plants, and early commercial production. The costs do not address incentives needed by feedstock producers, including costs to establish feedstock collection and distribution infrastructure. Those are addressed under AFW-7.

**Key Assumptions:** Starch-based ethanol production using renewable fuels could achieve significant GHG life cycle benefits over conventionally produced starch-based ethanol; however, the analysis above does not assume that any of the starch-based ethanol is produced using GHG-superior methods. For costs, this analysis assumes that existing State incentives are sufficient for promoting additional starch-based production; federal tax incentives do not preclude the need for the additional state incentives assumed for the cost estimate.

### Key Uncertainties

Oil market volatility; favorable federal legislation for ethanol.

Federal support for cellulosic research and design.

Ability to harvest and transport biomass cost effectively (see AFW-7).

Forest biomass generated is dependent on logging activity (e.g., logging slash addressed under AFW-7) and assumes that current levels of logging activity will occur into the future. Forest biomass could also come from forest thinning projects, which would then be dependent on the number of forest acres and level of thinning treatment (biomass density reduction). This can be greatly impacted by budget limitations, state and federal forest policies, and forest management litigation or appeals.

### Additional Benefits and Costs

**Agricultural residue:** increase in value added to crop production.

**Fossil fuel dependence:** dependence on foreign fossil fuels reduced; higher revenues for energy producers within the state.

### Feasibility Issues

Impacts on food and animal feed production with increases in starch-based ethanol production; water availability to produce significant quantities of starch-based feedstocks. Cellulosic feedstocks (500,000 dry tons by 2020 needed, as shown above) are expected to come from utilization of crop residue (see AFW-7).

For the agricultural sector, a study by the US DOE National Renewable Energy Laboratory (NREL) estimates the amount of agricultural residue available in Montana to be 1,560,000 dry tons/year.<sup>17</sup> From NREL's assessment, CCS derived an estimate of 546,000 dry tons of residues

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<sup>17</sup> *A Geographic Perspective on the Current Biomass Resource Availability in the United States*. NREL, US DOE, NREL/TP-560-39181, December 2005. All estimates were developed using total grain production by county for

available each year. It is assumed that this biomass will fulfill the requirements for cellulosic feedstock under this option. Significant increases in production above the current goals would likely require additional biomass from other sources (e.g., purpose grown crops, forest biomass, and MSW fiber).

Sufficient biomass appears to be available to meet the levels of cellulosic ethanol production in the goal statement for 2020. There will be unused amounts of agricultural residue available between 2010 and 2020. However, it is assumed that it will take some time for the technology and markets to be available to gather, transport, and use this material effectively. The actual use of agricultural or woody biomass will be dependent on which technologies develop first and also on the location of the facilities, because eastern Montana has more agricultural biomass and western Montana has more wood.

### **Status of Group Approval**

Completed.

### **Level of Group Support**

Unanimous consent.

### **Barriers to Consensus**

None.

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2002 reported to the USDA. Quantities that must remain on the field for erosion control differ by crop type, soil type, weather conditions, and the tillage system used. It was assumed that 30% residue cover is reasonable for soil protection. Animals seldom consume more than 20%–25% of the stover in grazing, and NREL presumes about 10%–15% of the crop residue is used for other purposes such as bedding and silage. Therefore, it was assumed that about 35% of the total residue could be collected as biomass. CCS used the policy goal of 10% of agricultural residue to adjust the NREL estimate (i.e., NREL estimate of 1,560,000 dry tons/year  $\times$  10%/35%).

## AFW-4. Incentives for Enhancing GHG Benefits of Conservation Provisions of Farm Bill Programs

### Policy Description

Agricultural lands that have been placed into conservation programs such as those established through the 2002 Farm Bill may sequester carbon dioxide by implementing practices that build soil carbon over time. For example, land in the CRP is taken out of production and, in the absence of tillage practices, soil carbon is sequestered over time. This option seeks to extend the GHG benefits of current Farm Bill programs, looking particularly at land that is scheduled to retire from Farm Bill programs and potentially return to production.

### Policy Design

**Goals:** For acreage that is being retired from conservation programs, retain these crop acres in some type of management program that protects the soil carbon.

**Timing:** Achieve no net conversion of acreage in conservation programs to conventional tillage by 2010. Retain no net conversion through 2020.

**Parties Involved:** Montana DNRC, MDOA, conservation districts, USDA agencies including the NRCS, the Farm Services Agency, and the USFS.

**Other:** This strategy would be a low-cost option that would bring to bear the existing federal and state staff and programs in a focused approach unlike any other in the United States.

### Implementation Mechanisms

**Leverage existing federal and state conservation cost share programs:** State agencies would incorporate USDA-approved carbon sequestration planning criteria into program literature, staff training, and technical assistance to landowners desiring to develop a carbon sequestration project for entry into the NCOC portfolio.

The Montana DNRC and the Montana conservation districts would include terrestrial carbon sequestration benefits, emerging carbon market information, and established state or national carbon sequestration planning criteria in their program literature. Conservation district staff would be trained to provide such information and technical assistance to landowners desiring to develop carbon sequestration projects for entry into emerging voluntary or federally mandated carbon markets. Such a program would help Montana landowners and tribal governments use existing federal and state conservation practice standards and cost share programs when entering into private carbon credit trades, thus increasing incentives for conservation and carbon sequestration practices.

**Education and training:** Implementation of this strategy would include a series of training workshops and print and Web-based materials for inclusion in existing outreach efforts.

## Related Policies/Programs in Place

NRCS CRP rewards farmers financially for removing highly erodible and marginally productive land from production. CRP is currently capped at 25% of Montana cropland per county.

## Type(s) of GHG Reductions

Net CO<sub>2</sub> is reduced by maintaining agricultural conservation lands in an uncultivated (untilled) condition. When soil carbon is exposed to air following tillage, this carbon is oxidized and lost to the atmosphere as CO<sub>2</sub>. Additional reductions through lower fossil fuel consumption than would otherwise be used to actively till land.

## Estimated GHG Savings and Costs per MtCO<sub>2</sub>e

**GHG Reduction Potential in 2010, 2020 MMtCO<sub>2</sub>e):** 0.50, 1.61.

**Net Cost per MtCO<sub>2</sub>e:** \$12.

*These GHG reductions were left out of the cumulative totals for the AFW sector in the summary table at the front of this document, since they refer to soil carbon benefits that would occur if the CRP acres were returned to active cultivation using conventional tillage. Since this scenario was not included in the BAU forecast in the Inventory and Forecast, the emission reductions cannot be taken against the existing future emission estimates. Note that this policy option is needed to ensure that soil carbon losses do not occur on retiring CRP acres.*

**Data Sources:** Data on the number of acres expiring from CRP as of 2007 were obtained from a USDA monthly CRP acreage report for May 2007.<sup>18</sup> Estimates of the percentage of expiring acres that were offered extensions or reenrollment were taken from USDA CRP state data tables<sup>19</sup> and a report from Ducks Unlimited.<sup>20</sup> Average annual CRP rental payments were taken from USDA state data tables.

The change in soil carbon due to CRP acres returned to conventional tillage or development was taken from a report from the Food and Agricultural Policy Research Institute. This report shows that the effects of conventional crop production in Montana are in the range of –3.9 to –2.0 tons of carbon (C) per acre and the effects of the CRP in Montana are 1.1 to 5.0 tons C/acre over 10 years. Adding the midpoint of these two ranges results in 6 tons C/acre (20 MtCO<sub>2</sub>e/acre).

**Quantification Methods:** The number of acres leaving the CRP program for each year was estimated using the number of acres expiring for 2008–2020 as of 2007. These acreages do not include extensions and reenrollments. Therefore, 91.6% of expiring acres were assumed to be offered extensions or reenrollments with 93.3% accepting the offers (based on USDA data for 2006). For the acres accepting offers, 32.2% are assumed to be reenrollments (10-year contract) and 67.8% are assumed to be extensions (based on data in the Ducks Unlimited report cited

<sup>18</sup> USDA, Farm Service Agency, Monthly CRP Acreage Report, <http://content.fsa.usda.gov/crpstorpt/rmepegg/MEPEGGR1.HTM>.

<sup>19</sup> USDA, Farm Service Agency, CRP State Tables, August 2006.

<sup>20</sup> Ducks Unlimited, “Conservation Reserve Program: Critical Waterfowl Nesting Habitat at Risk in the Prairie Pothole Region” [http://www.ducks.org/media/Conservation/Farm%20Bill/\\_documents/CRP\\_021007.pdf](http://www.ducks.org/media/Conservation/Farm%20Bill/_documents/CRP_021007.pdf)

above). The contract extensions are divided equally between 2-, 3-, 4-, and 5-year extensions. Table I-5 shows the estimated number of acres leaving CRP for 2001–2020. The number of acres leaving CRP was then multiplied by the soil carbon change between conventional crop production and CRP management.

**Table I-5. Estimated number of acres leaving CRP for 2001–2005**

Year	CRP Acres Set to Expire (2007)	Acres Expiring Including Reenrollments and Extensions	Active Acres Estimate	Acres Leaving Program
2007	618,435	618,435	3,387,546	89,903
2008	190,425	190,425	3,359,863	27,682
2009	307,871	397,457	3,302,084	57,779
2010	409,680	526,851	3,225,495	76,589
2011	493,060	667,806	3,128,414	97,080
2012	645,081	896,147	2,998,140	130,275
2013	362,907	621,124	2,907,846	90,294
2014	235,108	595,556	2,821,268	86,577
2015	115,767	508,615	2,747,330	73,938
2016	40,814	443,614	2,682,841	64,489
2017	332	550,260	2,602,848	79,992
2018	23,234	389,825	2,546,179	56,670
2019	1,778	415,076	2,485,838	60,340
2020	26,312	445,415	2,421,087	64,751
2021	6,646	450,989	2,355,526	65,561
2022	0	507,441	2,281,758	73,768

Costs were estimated by applying the cumulative number of acres leaving CRP by the annual rental payment (\$34/acre).

**Key Assumptions:** No new acres will be enrolled into CRP and the current level of reenrollment and extensions will continue.

### Key Uncertainties

It is not certain that all of the acres leaving CRP would return to active production; for those returning to active production, it is also unclear whether it would be to annual or perennial crops (this analysis assumes annual crops that require conventional tillage each year).

### Additional Benefits and Costs

None identified.

### Feasibility Issues

Implementation of this policy option needs to consider additional programs targeted at production practices that conserve soil carbon and net GHG benefits as alternatives to programs like CRP. CRP programs are sometimes being used for retirement income by older farmers, which creates a disincentive for removing the lands from the CRP program. These acres could be returned to production with conservation practices that would not necessarily need to be plowed;

for example, they could be used for grazing. Use of acres in this manner would allow for economic growth in the agriculture industry, provide an opportunity for young farmers to use the land, and provide for growth of businesses providing support services.

#### **Status of Group Approval**

Completed.

#### **Level of Group Support**

Unanimous consent.

#### **Barriers to Consensus**

None.

## AFW-5. Preserve Open Space and Working Lands – Agriculture and Forests

### Policy Description

Reduce the rate at which existing crop/pasture, rangeland, and forests are converted to developed uses. The carbon sequestered in the soils and aboveground biomass of these open spaces and working lands is often much higher than in developed land uses. Policies that preserve open space and working lands provide additional GHG benefits by reducing the vehicle miles traveled that would otherwise occur from unwise or unplanned development (note relationship to growth and development under TLU-5).

### Policy Design

**Goals:** By 2020, reduce the rate at which forest and agricultural lands are converted to developed use by 50% from current levels.

**Timing:** By 2015, reduce the rate of conversion by 25%; achieve full 50% by 2020.

**Parties Involved:** Montana DNRC; Montana Fish, Wildlife, and Parks (FWP); USFS; USDA NRCS; county governments and other political subdivisions of the state; private nonprofit land trusts; nonprofit organizations; Alternative Energy Resources Organization (AERO); Montana Farmers Union; and other farm groups.

**Other:** NRCS National Resources Inventory (NRI) data (1987–2003) shows that Montana is losing (on average) more than 2,000 acres of forestland and more than 34,000 acres of rangeland on an annual basis. While some of that rangeland is turning into pastureland, more than 13,000 acres a year (on average) is being developed or becoming other rural lands. There is potential for divestiture of more than 1 million acres of industrial forestland and loss of more than 5 million acres of ranchlands, with some proportion of those lands being converted to development. There were more than 14,500 new subdivisions approved by local governments over the past 10 years, resulting in more than 1.1 million acres of new development. Projections are 200,000 more people in the next 20 years, with more than 100,000 additional homes in western Montana by 2025.

### Implementation Mechanisms

- Develop a mitigation fund where developers would contribute and funds would be used to offset impacts (e.g., conservation easements).
- Engage local/county planning boards and zoning departments.
- Engage tourism departments and land trusts in the solution.

### Related Policies/Programs in Place

**State Programs:** There are several existing state programs aimed at conserving lands that provide important wildlife habitat. The Habitat Montana program administered by FWP uses

hunting license fees to protect threatened wildlife habitats. Montana's FWP Wildlife Mitigation Program aims to replace wildlife and habitat lost during the development of Libby and Hungry Horse Dams. FWP state wildlife grants use federal funding through the Land and Water Conservation Fund for projects involving species of special concern and can potentially be used for land and easement acquisitions. The Natural Resource Damage Program under the Montana Department of Justice (DOJ) uses funds recovered from an environmental lawsuit to fund restoration in the Clark Fork Drainage area. The funds can be used for land and easement acquisitions.

**Federal Programs:** There are also several federal programs that have been critical for funding land conservation through fee or easement purchases. The Forest Legacy Program provides funding to protect environmentally sensitive forestlands. The Habitat Conservation Plan Land Acquisition Grants Program provides funding for acquisition of vital habitat for threatened and endangered fish, wildlife, and plants. At the county level, Gallatin, Ravalli, and Missoula counties have passed \$40 million in bonds to protect open space, particularly agricultural land that is rapidly being converted for subdivisions.

### Type(s) of GHG Reductions

**CO<sub>2</sub>:** Avoided emissions from carbon sequestered in biomass and soils that sequester carbon, as long as they are not disturbed by development and conversion to developed uses. The conversion of existing forests and agricultural lands to developed use releases carbon that has previously been sequestered and hinders future sequestration.

### Estimated GHG Savings and Costs per MtCO<sub>2</sub>e

#### I. Agriculture

**GHG Reduction Potential in 2010, 2020 (MMtCO<sub>2</sub>e):** 0.003, 0.02.

**Net Cost per MtCO<sub>2</sub>e:** \$32.

*Note: The reductions and cost per Mt estimated for this option refer only to the direct benefits and costs associated with the estimated loss of soil carbon from agricultural soils due to development. They do not include the indirect benefits that occur as a result of more efficient development patterns that could result from this option (see TLU-5).*

#### Data Sources:

The annual rate of agricultural land conversion in Montana is 7,200 acres per year.<sup>21</sup> The typical level of soil carbon in agricultural soils is estimated by comparing soil carbon and cropland maps from the United States Geological Survey (USGS). These maps show that the areas of Montana with the most agriculture have soil carbon stocks ranging from 0.1 to 4.0 kg C/m<sup>2</sup> in the top 20 cm. About half of the area is in the 0.1 to 2.0 kg C/m<sup>2</sup> range and about half is in the 2.1 to 4.0 kg C/m<sup>2</sup> range. The midpoint of this range—2.0 kg C/m<sup>2</sup>—is equivalent to 0.008 MMtC/1,000 acres. The cost of establishing conservation easements on agricultural lands

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<sup>21</sup> NRI data provided by Julie Tesky, State Resource Inventory Coordinator, USDA, NRCS, Montana State Office. Includes agriculture and rangelands.

surrounding developing areas was estimated by dividing the total costs for eight easements preserved through the Montana Agricultural Heritage Program by the total acreage for these easements.<sup>22</sup> The resulting average net policy cost is \$730/acre.

## **Quantification Methods:**

### *GHG Benefits*

Studies are lacking on the changes in below- and aboveground carbon stocks when agricultural land is converted to developed uses. For some land use changes, carbon stocks could be higher in the developed use relative to the agricultural use (e.g., parks). In other instances, carbon stocks are likely to be lower (graded and paved surfaces). CCS assumed that the agricultural land would be developed into typical tract-style suburban development. It was further assumed that 50% of the land would be graded and covered with roads, driveways, parking lots, and building pads. The final assumption was that 75% of the soil carbon in the top 8 inches of soil for these graded and covered surfaces would be lost and not replaced. CCS assumed no change in the levels of aboveground carbon stocks.

The benefit in each year was determined by a) determining the amount of land protected in each year by multiplying the annual rate of agricultural land lost by the percent of agricultural land protected; b) multiplying the soil carbon content on the protected land by 50% (representing graded and covered areas) and by 75% (fraction of soil carbon lost); and c) converting the soil carbon lost to CO<sub>2</sub> by multiplying by 44/12.

### *Costs*

To estimate program costs in each year, CCS used multiplied the estimated agricultural acres protected from development by the conservation cost (\$730/acre) and an assumed cost share of 50%. This cost share is assumed to be available from the NRCS or other sources (e.g., city or county governments or nongovernment organizations). The resulting cost-effectiveness is \$32 per MtCO<sub>2</sub>e. This estimate accounts for only the direct reductions associated with soil carbon losses estimated above and does not include potentially much larger indirect benefits associated with reductions in vehicle miles traveled (see TLU-5).

Note that the availability of this cost share is a significant assumption for this policy option, since the number of acres to be protected is substantially higher than the average number of acres protected during the 1996–2001 period (about 200 acres/year). Without the cost share, the cost-effectiveness would be twice the value presented here.

**Key Assumptions:** No change in aboveground carbon stocks; 75% loss of soil carbon on 50% of developed land; 50% cost share available from NRCS, city or local governments, or other sources.

## **II. Forests**

**GHG Reduction Potential in 2010, 2020 (MMtCO<sub>2</sub>e): 0.03, 0.14.**

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<sup>22</sup> The Montana Agricultural Heritage Program approved eight landowner grant applications totaling \$888,000. This figure is to be matched by an additional \$6.36 million from various federal, local, and private sources, including the participating landowners. The corresponding easements preserve 9,923 acres. <http://www.westgov.org/wga/publicat/pdr.pdf>.

**Cumulative GHG Reduction Potential (MMtCO<sub>2</sub>e, 2007–2010): 0.9.**

**Net Cost per MtCO<sub>2</sub>e: \$3.**

**Data Sources:**

Forestry—USFS Methods for Calculating Forest Ecosystem and Harvested Carbon with Standards Estimates for Forest Types of the US, General Technical Report NE-343 (also published as part of the US DOE Voluntary GHG Reporting Program). Data on forest conversion to developed uses from NRCS NRI (1987–2003). Data on forest types from the Forest Inventory Analysis (FIA), 2003–2005. T.F. Strong, 1997 “Harvesting Intensity Influences the Carbon Distribution in a Northern Hardwood Ecosystem,” USFS Research Paper NC-329; “The Intersection of Land Use History and Exurban Development: Implications for Carbon Storage in the Northeast” master’s thesis, K. Austin, 2006.

**Quantification Methods:**

Carbon savings from this option were estimated from two sources: 1) the amount of carbon that would be lost as a result of forest conversion to developed uses (i.e., avoided emissions) and 2) the amount of annual carbon sequestration in protected forest area. The area of forestland protected annually is based on a gradual implementation of the goals outlined above, so that a 25% reduction in forest conversion rates is achieved by 2015 and a 50% reduction by 2020. A current conversion rate of 2,000 acres/year was assumed based on NRI data from 1987 to 2003. The percentages in the goals represent a decrease from the current conversion rate of 500 acres/year in 2015 and 1,000 acres/year in 2020. Table I-6 shows the assumptions about the types of forests protected under this option, based roughly on relative abundances of three common forest types in Montana. Table I-6 also provides values for forest carbon stocks and annual carbon flux used to calculate total carbon savings under this option.

**Table I-6. Input data, by forest type**

<b>Forest Type</b>	<b>Percent of Protected Acres</b>	<b>Annual C Flux (tC/acre/year)</b>	<b>Biomass Carbon Stocks (tC/acre/year)</b>	<b>Soil Carbon Stocks (tC/acre/year)</b>
Douglas fir	52%	0.573	66.0	15.7
Lodgepole pine	26%	0.388	44.0	15.0
Ponderosa pine	22%	0.368	45.0	13.9

The forest carbon stocks (tC/acre) and annual carbon flux (annual change in tC/acre) data are based on default carbon sequestration values for Douglas fir, lodgepole pine, and ponderosa pine forest types in the northern Rocky Mountain region of the United States (USFS GTR-343, Tables A30, A32, and A33). Values for forest carbon stocks (including biomass and soils) in each of the three forest types represent the average for typical mature forests and are based on coefficients for 65-year-old stands. Annual rates of carbon sequestration (tons carbon sequestered per year) were calculated by subtracting total carbon stocks in forest biomass of 125-year-old stands from total carbon stocks in forest biomass of new stands and dividing by 125. A long-term average was used to implicitly take into account the relatively fast rate of carbon accumulation in young stands and slower rates in older stands. Soil carbon density was assumed constant and is not included in the annual carbon flux calculations because default values for soil carbon density are constant over time in USFS GTR-343.

## A. Avoided Emissions

Loss of forests to development results in a large one-time surge of carbon emissions. In this case, it was assumed that 53% of carbon stocks in biomass and 35% of carbon stocks in soils would be lost in the event of forest conversion, with no appreciable carbon sequestration in soils or biomass following development. The biomass loss assumption is based on research that shows heavy levels of individual tree removal results in the harvesting of 53% of carbon in aboveground biomass (Strong, 1997). The soil carbon loss assumption was based on a study that shows about a 35% loss of soil carbon when woodlots are converted to developed uses (Austin, 2006). Therefore, to estimate avoided emissions, the total number of acres protected in a year for each forest type was multiplied by the percent-adjusted carbon stock value for loss of biomass and soil carbon stocks. Results were converted to units of MMtCO<sub>2</sub>e and are provided in Table I-7.

**Table I-7. Emissions avoided by protecting forestlands in Montana**

Year	Acres Protected	Avoided Emissions (MMtCO <sub>2</sub> e)			
		Douglas Fir	Lodgepole Pine	Ponderosa Pine	Total
2007	56	0.0043	0.0015	0.0013	0.007
2008	111	0.0086	0.0030	0.0026	0.014
2009	167	0.0129	0.0045	0.0039	0.021
2010	222	0.0171	0.0061	0.0051	0.028
2011	278	0.0214	0.0076	0.0064	0.035
2012	333	0.0257	0.0091	0.0077	0.043
2013	389	0.0300	0.0106	0.0090	0.050
2014	444	0.0343	0.0121	0.0103	0.057
2015	500	0.0386	0.0136	0.0116	0.064
2016	600	0.0463	0.0163	0.0139	0.077
2017	700	0.0540	0.0191	0.0162	0.089
2018	800	0.0617	0.0218	0.0185	0.102
2019	900	0.0695	0.0245	0.0208	0.115
2020	1,000	0.0772	0.0272	0.0232	0.128
<b>Total</b>	<b>6,500</b>	<b>0.50</b>	<b>0.18</b>	<b>0.15</b>	<b>0.83</b>

## B. Annual Sequestration in Protected Forests

The results for annual sequestration are given in Table I-8. Forests preserved in one year continue to sequester carbon in subsequent years. Thus, annual sequestration includes benefits from acres preserved cumulatively under the program. It was calculated each year by multiplying the cumulative acres protected by the percentage of each forest type and by the average annual carbon flux for each forest type.

**Table I-8. Annual carbon sequestered in protected forestlands**

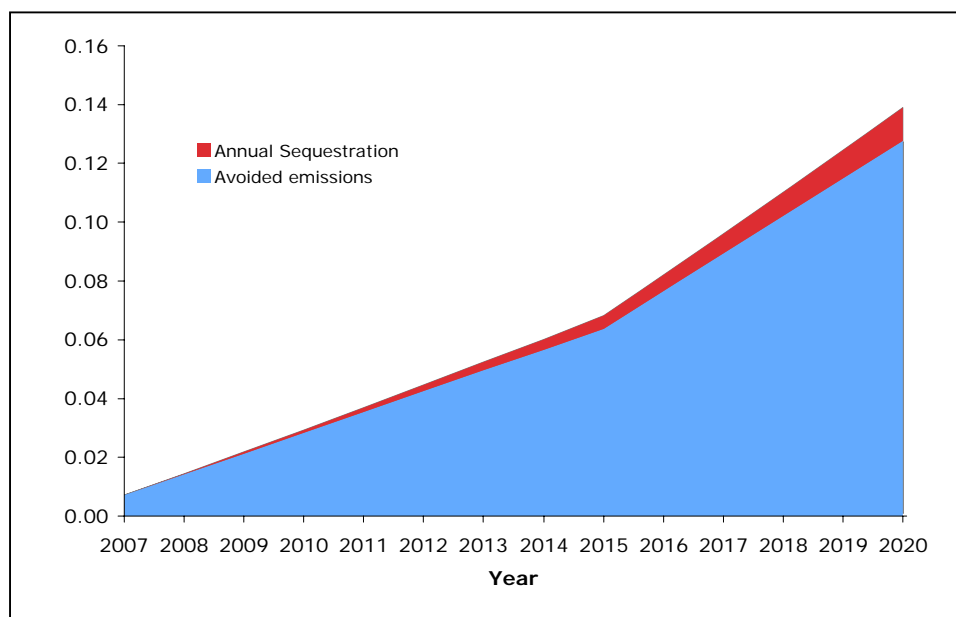
Year	Acres protected	Annual C Sequestered (MMtCO <sub>2</sub> e)			
		Douglas Fir	Lodgepole Pine	Ponderosa Pine	Total
2007	56	0.0001	0.0000	0.0000	0.0001
2008	167	0.0002	0.0001	0.0000	0.0003
2009	333	0.0004	0.0001	0.0001	0.0006
2010	556	0.0006	0.0002	0.0002	0.0010
2011	833	0.0009	0.0003	0.0002	0.0015
2012	1,167	0.0013	0.0004	0.0003	0.0021
2013	1,556	0.0017	0.0006	0.0005	0.0027
2014	2,000	0.0022	0.0007	0.0006	0.0035
2015	2,500	0.0027	0.0009	0.0007	0.0044
2016	3,100	0.0034	0.0011	0.0009	0.0055
2017	3,800	0.0042	0.0014	0.0011	0.0067
2018	4,600	0.0050	0.0017	0.0014	0.0081
2019	5,500	0.0060	0.0020	0.0016	0.0097
2020	6,500	0.0071	0.0024	0.0019	0.0114
<b>Total</b>	<b>6,500</b>	<b>0.036</b>	<b>0.012</b>	<b>0.0097</b>	<b>0.058</b>

**C. Total Carbon Savings**

Total carbon savings achieved by protecting forestlands from development are illustrated in Figure I-1. Figure I-1 shows that the bulk of carbon savings under this option arise from avoiding the emissions generated during conversion of forestlands to other uses.

The cost of protecting forestland was estimated at \$635/acre using expert input from the Montana land trust community. This value assumes that 20% of forests under this option will be acquired at \$2,500/acre, 10% of forests will be preserved with conservation easements costing \$1,000/acre, and 70% of forests will be preserved with donated conservation easements at \$50/acre. The analysis does not take into account potential cost savings from forest products revenue on working forestlands that are protected under this policy. Annual costs were estimated by multiplying the number of acres protected by the cost per acre. Annual discounted costs were then estimated using a 5% interest rate. The cumulative cost-effectiveness of the total program was calculated by summing the annual discounted costs and dividing by cumulative carbon sequestration, yielding \$3/MtCO<sub>2</sub>e. The sum of annual discounted costs also provides an estimate of the net present value (NPV) of this option of \$2.7 million.

**Figure I-1. Total carbon savings from protecting forestlands**



**Key Assumptions:** Forestry: 53% and 35% of biomass and soil carbon, respectively, is lost when forests are converted to developed uses; no appreciable carbon sequestration occurs post-development. Distribution of forest types protected is assumed based on forest dominance.

### Key Uncertainties

Levels of above- and belowground carbon stored in agricultural lands versus developed land uses; costs of both agricultural and forestland protection programs; potential for leakage (working lands protected in one area force a similar level of development in a different area).

### Additional Benefits and Costs

Supporting intact rural communities in traditional land uses; maintaining land for recreational opportunity (hunting and fishing), critical wildlife habitat, productive timberland, and water quality.

Potential to enhance smart-growth objectives.

Potential loss of commercial income generating activity.

### Feasibility Issues

Lack of funding at federal, state, and local level.

Difficulty in requiring how private property will be used.

Difficulty in determining the total number of acres that need to be protected (total number with the potential for development within the policy period) in order to achieve the policy goals for reducing conversion to developed use. For example, the costs for the agricultural land conversion goal is based on protecting the exact number of acres that have been protected from

development, not the total number of acres that need to be protected in order to achieve the conversion goal (50% reduction in conversion by 2020). In order to prevent leakage (the same level of development occurring in another location after reducing conversion in a target area), it is highly likely that a much larger number of acres will need to be protected via conservation easements or acquisition than reported above. Additional study is needed on areas that should be targeted for protection in order to implement this policy and inform policy makers on the potential costs.

#### **Status of Group Approval**

Completed.

#### **Level of Group Support**

Unanimous consent.

#### **Barriers to Consensus**

None.

## AFW-7. Expanded Use of Biomass Feedstocks for Energy Use

### Policy Description

This policy seeks to expand the use of biomass from forests, agriculture, and other sources for energy. Biomass can be used to produce liquid fuels, including cellulosic ethanol, or to produce energy in the form of electricity, heat, or steam. The latter is covered by this option.

Carbon in biomass is considered biogenic under sustainable systems; carbon dioxide emissions from biomass energy combustion are replaced by future carbon sequestration in new biomass. Expanded use of biomass energy in place of fossil fuels results in net emissions reductions by shifting from high- to low-carbon fuels (when sustainably managed), provided the full life cycle of energy requirements for producing fuels does not exceed the energy content of the renewable resource. Expanded use of biomass energy can be promoted through increasing the amount of biomass produced and used for renewable energy and providing incentives for the production and use of renewable energy supplies.

### Policy Design

**Goals:** Increase usage of woody biomass residue for renewable electricity, heat, and steam generation to 450,000 tons/year by 2020. To use 540,000 dry tons of agricultural residues utilized annually by 2020.<sup>23</sup>

**Timing:** See above.

**Parties Involved:** Montana DNRC, MDEQ, USFS, BLM, MSU Cooperative Extension Service, University of Montana College of Forestry and Conservation, Montana PSC, industrial and commercial energy providers and consumers, livestock and poultry producers, farmers, private landowners, forest products manufacturers, and logging companies.

**Other:** The current estimated amount of biomass used in Montana is 2 million dry tons, with 1.95 million derived from primary and secondary mill waste and only 85,000 tons from logging residue. It is estimated that there is 2.76 million dry tons of woody biomass available in Montana (US DOE, NREL), with 704,000 dry tons available annually from logging residue. Therefore, one of the goals will be to increase the utilization of woody biomass from logging residue. That amount would be used under this option to supply fuel for producing electricity, steam, and heat. As the acreage being treated to reduce fire hazards in the state increases, the total amount of available biomass will also increase.

### Implementation Mechanisms

**State Lead by Example:** Require consideration of renewable resource systems (including biomass heat/energy) in all new state building constructions and renovations and provide state

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<sup>23</sup> 540,000 dry tons is one-third of the estimated agricultural residues available from a study by the US DOE NREL. *A Geographic Perspective on the Current Biomass Resource Availability in the United States*, A. Milbrandt, Technical Report, NREL/TP-560-39181, December 2005.

support to the DNRC Biomass Utilization Fuels for Schools Program and Beyond which identifies financially viable biomass heating opportunities and helps facilities secure funding, supply, and installation. State lands should incorporate biomass recovery objectives during program implementation.

**Source Reduction:** Reduce the amount of open slash pile burning on all lands and/or provide viable alternatives to open burning. Revise MDEQ air quality permits and local ordinances to discourage open burning and continue to encourage alternatives.

**Voluntary/Negotiated Agreements:** Voluntary, incentive based programs should be used to foster the development of the industry and associated economic markets. Provide landowners and/or corporations with opportunity to enter into agreements to better utilize biomass energy and/or increase the productivity of carbon sequestered on the landscape.

**Funding Mechanisms:** Provide tax incentives to reduce the capital costs of biomass energy production, including electricity generation and heating of residences and public buildings; establish utility “Buyback Rates” for biomass-derived energy where utilities offer a standard rate for which they purchase biomass-generated energy (electricity and/or heat). Expand or develop renewable energy tax credits to provide new incentives for smaller distributed biomass generation.

**Pilots and Demonstrations:** Pilot projects on the use of different forestry (e.g., bio-refineries) and agriculture residues (e.g., cellulosic ethanol plants) for energy production are needed, as are pilot projects to demonstrate the transportation, collection, storage, and distribution infrastructure.

**Research and Development:** Research is needed on techniques for collecting and processing forestry and agriculture residues, as well as market development or expansion for these materials. Research is also needed to characterize emissions from biomass boilers to better characterize impacts on community air pollution and ways to minimize those impacts.

**Market-Based Mechanisms:** Incentives (e.g., preferential tax rates) may be needed to spur the use of biomass energy.

**Provide Tax Incentives:** Incentives to reduce the capital costs of biomass energy production and transport for use in liquid fuels production, electricity generation, and heating residences and commercial buildings. This could include gross receipts exemptions for biomass generation facilities, project construction, and related equipment and materials. Additional tax incentives have been put in place as a result of HB 3 in the Special Session of the 2007 Legislature. Analysis of the new incentives and any additional recommendations will be needed.

**Establish Utility “Buyback Rates” for “Feed-in-Tariffs”:** Applicable to biomass-derived energy where utilities offer a standard rate at which they purchase biomass generated energy (electricity and/or heat). Buyback rates for biomass projects in other regions of the country generally range from 6 to 7¢/kWh.

**Expand the Montana Renewable Energy Tax Credit:** Lower the eligible threshold capacity from 10 MW to 1 MW and expand the classification of corporate taxpayers and include general income taxpayers.

**Codes and Standards (State):** Expand existing net-metering regulations to enable smaller projects of up to 2 MW to net-meter at retail energy rates. (Net-metering enables customers to use their own generation to offset their consumption over a billing period by allowing their electric meters to turn backwards when they generate electricity in excess of their demand, feeding it back to the grid.)

**Codes and Standards (Local):** Work with local communities to develop responsible ordinances and continue to evaluate and discuss those that allow the use of US EPA–certified wood/pellet burning equipment (instead of broad burn bans that apply to all wood-burning equipment). Expand existing net-metering regulations to enable projects of up to 2 MW to net-meter at retail energy rates. Work with regional and national efforts to increase efficiency standards for wood-burning equipment (e.g., furnaces, stoves, boilers).

### **Related Policies/Programs in Place**

**Renewable Portfolio Standards:** Requires public utilities to obtain 15% of their retail electricity sales from eligible renewable resources by 2015.

**Renewable Energy Credits:** Create market for clean power generated by biomass. Western Governors' Association and California Energy Commission are currently working together to develop Western Renewable Energy Generation Information System (WREGIS), a regional renewable energy tracking and registry system.

**Alternative Energy Revolving Loan Program:** Provides loans to individuals, small businesses, local government agencies, units of the university systems, and nonprofit organizations to install alternative energy systems that generate energy for their own use. Maximum loan amount is \$40,000 with a fixed interest rate, and the loan must be paid back within 10 years.

**Montana Electric Cooperatives–Net-Metering:** Under the model policy, customers generating their own electricity using (but not limited to) wind, solar, geothermal, hydro, biomass, or fuel cells may participate in net-metering.

**Mandatory Green Power Program:** NorthWestern Energy (NWE) offers its customers the option of purchasing a product composed of or supporting power from certified environmentally preferred resources generated by renewables including biomass.

**DNRC Forestry Assistance Programs:** Maintain and improve the health of Montana's forests, forested watersheds, and the communities that depend on them. Tools include information and education, technical assistance, and financial assistance.

**Biomass Utilization Fuels for Schools and Beyond Program:** Promote the use of forest biomass as an energy source for heating schools and other public facilities. Use of biomass energy for heat and energy creates carbon offsets when compared with use of fossil fuels.

**USFS Woody Biomass Utilization Policy:** Recently implemented, it requires that contractors doing work on federal lands haul and pile slash at landings to help facilitate removal of biomass during forest operations for utilization.

**State Trust Lands Forest Management Program:** Recently implemented, the Forest Management Bureau has changed the timber bid sale process for state trust lands to encourage removal of residues for pulp and biomass.

### **Type(s) of GHG Reductions**

Avoided fossil fuel emissions (primarily CO<sub>2</sub>, but also CH<sub>4</sub> and N<sub>2</sub>O) through the use of lower carbon liquid and solid fuels.

### **Estimated GHG Savings and Costs per MtCO<sub>2</sub>e**

**GHG Reduction Potential in 2010, 2020 (MMtCO<sub>2</sub>e):** 0.04, 0.15.

**Net Cost per MtCO<sub>2</sub>e:** –\$23.

ES and RCII options related to increasing energy generation from renewable energy sources include biomass energy generation. This policy calls for the utilization of 450,000 tons of woody biomass by 2020. GHG reductions from avoided fossil fuel use associated with this AFW option are almost fully accounted for in the quantification of the ES/RCII renewable fuels options. The total inferred biomass tonnage included in the quantification of the relevant ES/RCII options is approximately 161,000 dry tons. This leaves 289,000 dry tons of additional woody biomass per year that could also be used to offset fossil fuel combustion in the ES or RCII sectors. It is assumed that no additional woody biomass from the mill waste is available. Therefore, the additional biomass is assumed to come from logging slash. Subtracting the estimated 85,000 tons of current utilization and assuming that the BAU utilization doesn't change between 2006 and 2020 leaves a total increase in woody biomass of 204,000 dry tons (450,000 dry tons from logging slash minus 161,000 dry tons used by RCII minus 85,000 BAU consumption). The benefit for this additional biomass is quantified here, assuming that the biomass is used to offset natural gas consumption (higher benefits would occur if higher carbon fuels like coal or oil were offset).

The cost analysis for this option is based on the difference in costs between a supply of woody biomass fuel and the assumed fossil fuel that it is replacing (for the purposes of this analysis, natural gas). The cost of natural gas is assumed to be \$9.50/MMBtu, which is a nominal cost across residential, commercial, and industrial users based on 2005 data.<sup>24</sup> The cost of supplying biomass is \$130/ton (see fuel cost comparison chart, Figure I-2). This value compares to an estimate of \$140/ton associated with an 80-mile radius between supply and use and a cost of \$108/ton for a 25-mile radius in a recent study on western biomass supply and use.<sup>25</sup>

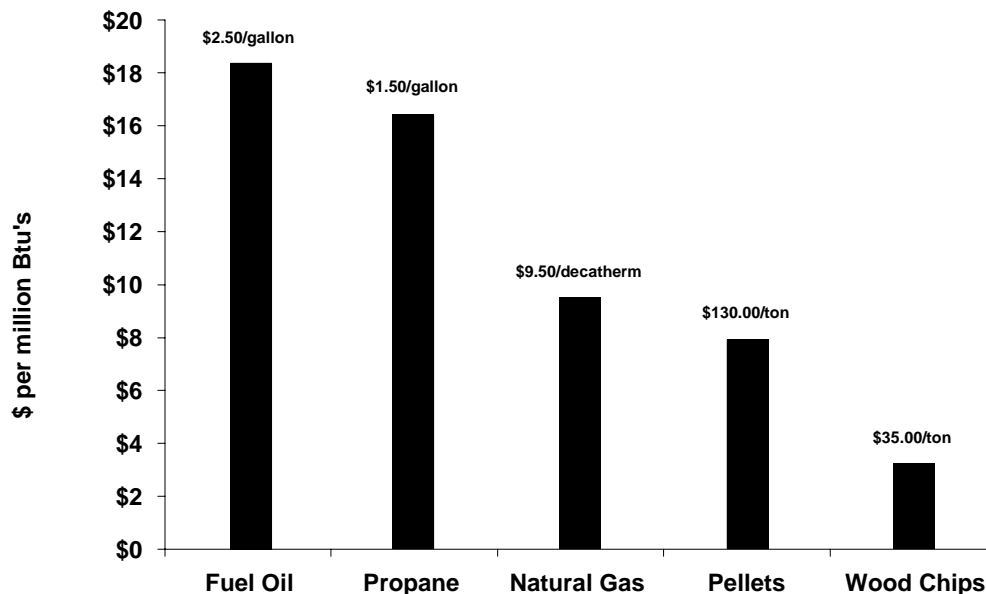
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<sup>24</sup> Source MDEQ: [http://www.deq.state.mt.us/Energy/HistoricalEnergy/Natural\\_gas\\_tables\\_2006\\_FINAL.htm](http://www.deq.state.mt.us/Energy/HistoricalEnergy/Natural_gas_tables_2006_FINAL.htm). Note that there are about 1,029 Btu per cubic foot of natural gas. Note also that trends in natural gas pricing show substantial increases during the past 5 years.

<sup>25</sup> Based on 80-mile radius, dry ton basis. From McNeil Technologies Report: *Western Regional Biomass Energy Program*, Final Report, Evaluating Biomass Utilization Options for Colorado: Summit and Eagle Counties, 2003.

The cost estimates do not include capital costs for new equipment purchases or retrofits. It is assumed that changes in equipment use occur after the useful life of existing fossil fuel-fired equipment. The up-front cost of a biomass combustion system can be greater than a traditional system; however, the fuel is far less expensive, such that, over time, fuel savings can more than offset up-front costs (as shown below). Net cost savings are more likely in certain circumstances, in particular a) when the price of fossil fuel equipment options are relatively expensive and b) in larger, heat-using facilities whose unit savings on heating fuel costs result in a better payback on the up-front investment. Figure I-2 shows costs relative to heat generation for various fuel sources.

**Figure I-2. Fuel cost comparison**



Source: Angela Farr, Fuels for Schools Program Coordinator, DNRC.

For costs associated with the establishment of a biomass fuels collection, processing, and distribution industry (e.g., incentive programs), these are assumed to be adequately captured within the cost estimates made for the applicable biomass energy option. For example, the price paid for delivered biomass energy under the ES or RCII options is assumed to be sufficient to drive the establishment of fuel collection, processing, and distribution. Similarly, for the use of biomass to produce liquid fuels, the costs are captured within the costs estimated for AFW-3.

**Data Sources:** For the quantification of benefits in the other associated biomass consumption options, see ES-1, ES-4/RCII-7, RCII-5/RCII-12, and AFW-3.

**Quantification Methods:** For the quantification of benefits in the other associated biomass consumption options see ES-1, ES-4/RCII-7, RCII-5/RCII-12, and AFW-3.

**Key Assumptions:** A key assumption on the costs is that there is no significant increase in capital costs associated with any equipment purchases or retrofits for end-users who switch over from fossil fuel-fired equipment to biomass equipment. Costs for delivering biomass and natural

gas are assumed to remain at current estimated levels. The benefits are based on offsetting natural gas consumption. Potentially greater benefits would be gained by offsetting other fossil fuels (coal and oil).

### **Key Uncertainties**

The amount of logging residues generated is dependent on timber harvesting and agricultural crop residues on crop production. Through 2020, timber harvesting and agricultural crop production are assumed to remain at current levels. Additional sources of biomass could be residues from forest thinning projects, purpose-grown crops (e.g., sweet sorghum), or MSW fiber. These additional sources were not considered in this policy analysis.

### **Additional Benefits and Costs**

- Encourage management of forested lands by contributing to economically viable ways to remove hazardous fuels and maintain healthy forests.
- Provide opportunities for local forest-dependent economies to supplement their businesses based on supplying woody biomass to users.
- Reduce risk of severe wildfires and their negative impacts on habitats, homes, communities, and watersheds.
- Improve forest carbon sequestration potential with the thinning treatments of forests.
- Reduce emissions from open-pile slash burning (reductions in particulate matter, CH<sub>4</sub>, NO<sub>x</sub>, SO<sub>x</sub>, CO).
- Displace the emissions associated with the combustion of traditional fossil fuels of natural gas, propane, and fuel oil.
- Reduce dependence on foreign fossil fuels.
- In-state air pollutant and GHG emissions associated with collection and transport of biomass; these offset emissions associated with the production, processing, and transport of fossil fuels to a greater or lesser extent (quantification of net impacts was beyond the scope of this analysis).
- Distribute heat and energy sources for national security.

### **Feasibility Issues**

- Economic and efficient recovery and transportation of forest biomass feedstock.
- Forest management litigation or appeals on state and federal lands.
- Long-term availability of biomass feedstock supplies at low costs.
- Challenges in permitting and/or locating facilities in air quality non-attainment areas.

### **Status of Group Approval**

Completed.

**Level of Group Support**

Unanimous consent.

**Barriers to Consensus**

None.

## AFW-8. Afforestation and Reforestation Programs – Restocking and Urban Trees

### Policy Description

Increase carbon stored in forests through expanding the forestland base. Establishing new forests, either on historically non-forested land (“afforestation”) or on land that has not been managed as forestland for some time (“reforestation”) increases the amount of carbon in biomass and soils compared to preexisting conditions. Afforestation and reforestation accomplished with stocking, planting, and other practices (e.g., soil preparation, erosion control) can increase carbon stocks above baseline levels and ensure conditions that support forest growth.

### Policy Design

**Goals:** Ensure restocking on 20% of the accessible forestlands impacted by stand replacement fires since the year 2000 (estimated at 70,000 acres) to stocking rates of 200–400 trees/acre (depending on forest type). For future lands impacted by wildfire, restock forestlands impacted by stand replacement fires (estimated at 20,000 acres/year) within 5 years post-fire.

Plant 42,250 new trees in Montana communities by 2020 through programs such as DNRC’s Urban and Community Forestry (U&CF) Program.

**Timing:** By 2010, ensure restocking on 15,000 acres of accessible lands impacted by stand replacement fires since the year 2000; by 2020, ensure restocking on the remaining 55,000 acres. As stated in the goal above, for future fires, restock 30% of the high severity burned forestlands within 5 years post-fire. For the urban area goals, achieve them at a pace of 3,521 trees per year.

**Parties Involved:** Montana DNRC, USFS, UM School of Forestry and Conservation, conservation districts, watershed management groups, BLM, Bureau of Indian Affairs, Confederated Salish and Kootenai Tribe, USDA NRCS; private industry, nonindustrial private landowners.

**Other:** Since 2000, over 3.3 million acres have burned in Montana. It is roughly estimated that one-third of these have been forested acres, and of the forested acres, about one-third have been high severity burns that require some level of restocking. Some of these areas have been replanted; however there are an estimated 70,000 acres still requiring replanting. In addition, each year there are an estimated 20,000 acres/year of forests burned with high severity (stand replacement fires). Together, there is a need for restocking on about 25,000 acres/year on federal, state, and private lands in Montana between 2007 and 2020 to meet the goals of this policy. Reforestation costs are roughly \$180/acre.

A 2007 study (Potter et al.) estimates that there are more than 69 million acres of low-production rangelands in Montana that could be afforested to result in carbon gains. More realistically, only 8.9 million acres are available for afforestation because of precipitation and soil nutrient limitations. The potential results of afforesting 8.9 million acres could be the sequestration of more than 15 million tons of carbon annually.

However, a question remains on the efficacy of afforestation in Montana. The best possible means for afforestation could remain with the development of wind breaks, shelter belts, and riparian areas. As currently written, this policy pertains only to reforestation efforts on high severity burned areas and urban forestry goals.

The Montana DNRC U&CF Program has the goal of planting 3,250 trees (250 trees/year) during 2008–2020. There is the potential for more trees to be planted each year by cities, counties, and local organizations. A rough estimate of this potential was used in combination with the DNRC goal to arrive at the goal level for urban tree planting. Montana has 129 incorporated cities, towns, and county governments and an additional 100 communities receiving some or all of their technical assistance from the Montana U&CF Program to build the necessary infrastructure to achieve Tree City USA designation and sustainable community forestry programs. The goal stated above assumes that each of these 229 communities plant 10 trees per year, leading to roughly 3,000 trees planted per year (that number will range from 0 to more than 100; e.g., The Growing Friends of Helena plants approximately 100 trees/year). This in combination with the DNRC U&CF Program would be 3,250 trees/year or 42,250 trees by 2020.

### **Implementation Mechanisms**

**Information and Education:** Work through the MSU Extension Forestry program and DNRC's Forest Stewardship Program to educate private forest landowners on the importance and practice of stand regeneration, post-fire reforestation, and restocking.

**Technical Assistance:** Develop interagency partnerships with then NRCS, USFS State and Private Forestry, conservation districts, and the Montana DNRC to deliver comprehensive private forest landowner assistance and cost-share programs for forest management and post-fire rehabilitation. Develop interagency site-specific reforestation plans post-burn with planting targeted for stand replacement fires.

**Market-Based Incentives:** Support and engage in private sector markets for carbon sequestration that recognize the carbon benefits of forest management, urban forestry, and afforestation/reforestation (e.g., Chicago Climate Exchange). State participation further enhances state lead by example as an implementation mechanism.

**Enhance and Expand Conservation Seedling Nursery:** Utilize the DNRC Conservation Seedling Nursery to provide locally adapted and native seedlings for private forest and riparian area reforestation projects. Provide additional support and resources to this program in order increase the capacity for program delivery to state, federal, and tribal landowners and other conservation organizations.

**State Lead by Example:** On state trust lands, DNRC generally plants 700–1,000 acres per year. In 2007 that level will increase to 1,700 acres due largely to areas impacted by wildland fires.

**Forest Pest Management:** Provide assistance to nonindustrial forest landowners and others in identifying and managing forest insects and diseases.

**Biomass Utilization:** Promote the use of forest biomass as an energy source for heating schools and other public facilities.

**Forest Stewardship:** Promote forest stewardship by helping nonindustrial forest landowners acquire personal knowledge about their forest resources and develop and implement a forest management plan for their property.

### Related Policies/Programs in Place

**Forestry Best Management Practices:** Montana has no regulations that direct landowners to replant stands post-harvest or post-burn. However, forestry best management practices encourage rapid reforestation post-harvest.

**Long-Term Maintenance Goals:** On state trust lands, there are general rules for maintaining long-term productivity of forestlands but no specific rules aimed at reforestation. However, DNRC has an active reforestation program focused on areas where natural regeneration is not occurring or where there are issues with tree species composition.

**DNRC Forestry Assistance Programs:** Maintain and improve the health of Montana's forests, forested watersheds, and the communities that depend on them. Tools include information and education, technical assistance and financial assistance.

### Type(s) of GHG Reductions

Carbon sequestered in forest biomass.

Carbon sequestered in urban/suburban trees.

Displaced fossil emissions from reduced heating and cooling needs (as a result of increased shade and reduced wind impacts from urban and suburban trees).

### Estimated GHG Savings and Costs per MtCO<sub>2</sub>e

**GHG Reduction Potential in 2010, 2020 (MMtCO<sub>2</sub>e):** (A) Restocking: 0.09, 0.51; (B) Urban trees: 0.001, 0.006.

**Cumulative GHG Reduction Potential (MMtCO<sub>2</sub>e, 2007–2020):** (A) Restocking 3.4; (B) Urban trees: 0.04.

**Net Cost per MtCO<sub>2</sub>e:** (A) Restocking: \$12; (B) Urban trees: –\$3.

**Data Sources:** USFS Methods for Calculating Forest Ecosystem and Harvested Carbon with Standards Estimates for Forest Types of the US, General Technical Report NE-343 (also published as part of the US DOE Voluntary GHG Reporting Program); USFS Effects of Urban Forests and their Management on Human Health and Environmental Quality <http://www.fs.fed.us/ne/syearacuse/Data/data.htm>; Carbon Dioxide Reduction Through Urban Forestry, USFS PSW-GTR-171, McPherson and Sampson, 1999; Northern Mountain and Prairie Community Tree Guide: Benefits, Costs and Strategic Planning, McPherson et al., 2003.

**Quantification Methods:** Analysis of this option includes two parts: (A) restocking of forests impacted by wildfires and (B) urban tree planting.

## Part A: Restocking of Forests Impacted by Wildfires

Goal levels require replanting on 5,000 acres/year from 2008–2010 and 5,500 acres/year from 2011–2020 to restock a total of 70,000 previously burned acres by 2020. In addition, each year there will be an estimated 20,000 acres of forests burned at high severity stand replacement intensities, and this policy aims to restock all of those future burn sites as well. Thus, another 20,000 acres/year of future burns are assumed starting in 2009.

Assumptions used to calculate the carbon benefits achieved through restocking are shown in Table I-9. The proportions of area restocked with each species type are based on the approximate relative distributions of these three forest types in Montana. Carbon sequestration rates of restocked forests are from USFS GTR NE-343 tables B30, B32, and B33, which contain carbon densities on northern Rocky Mountain forests that have been afforested. Carbon sequestration rates were calculated by subtracting carbon stocks in 15-year-old stands from carbon stocks in new stands and dividing by 15. These rates are intended to reflect growth rates in young, recently established stands. It was assumed that in the absence of this restocking program, no carbon sequestration would occur on these sites (i.e., the baseline rate is assumed to be zero).

**Table I-9. Restocking assumptions**

Forest Types Restocked	Proportion of Area Restocked With This Species	C Sequestration Rate (tC/acre/year)
Douglas fir	50%	0.56
Lodgepole pine	25%	0.32
Ponderosa pine	25%	0.39

Forests restocked in one year continue to sequester carbon in subsequent years. Thus, the calculation of carbon sequestration each year is based on annual benefits from acres restocked cumulatively under the program. Annual carbon sequestration was calculated for each forest type, based on the proportions provided in Table I-9, and summed to achieve the total carbon benefits. Units were converted from tons carbon (tC) to MMtCO<sub>2</sub>e. Table I-10 shows the acreage treated under goal implementation and resulting carbon sequestration benefits.

**Table I-10. Acres restocked and resulting carbon sequestration**

Year	Acres Replanted		Carbon Sequestered (MMtCO <sub>2</sub> e/year)			
	Previous Burns	Future Burns	Douglas Fir	Lodgepole Pine	Ponderosa Pine	Total
2008	5,000		0.0051	0.0015	0.0018	0.0084
2009	5,000	20,000	0.0308	0.0088	0.0106	0.0502
2010	5,000	20,000	0.0565	0.0161	0.0195	0.0921
2011	5,500	20,000	0.0826	0.0236	0.0285	0.1348
2012	5,500	20,000	0.1088	0.0311	0.0376	0.1775
2013	5,500	20,000	0.1350	0.0386	0.0466	0.2202
2014	5,500	20,000	0.1612	0.0461	0.0556	0.2629
2015	5,500	20,000	0.1874	0.0535	0.0647	0.3056
2016	5,500	20,000	0.2135	0.0610	0.0737	0.3483
2017	5,500	20,000	0.2397	0.0685	0.0828	0.3910
2018	5,500	20,000	0.2659	0.0760	0.0918	0.4337
2019	5,500	20,000	0.2921	0.0835	0.1008	0.4764
2020	5,500	20,000	0.3183	0.0909	0.1099	0.5191
<b>Total</b>	<b>70,000</b>	<b>240,000</b>	<b>2.10</b>	<b>0.60</b>	<b>0.72</b>	<b>3.42</b>

Costs were estimated based on a restocking cost of \$180/acre (Whitney, DNRC, personal communication). Annual costs were calculated by multiplying the number of acres restocked that year with the cost per acre for restocking. Costs were discounted for future years using a 5% interest rate. A levelized cost-effectiveness (CE) of \$12.11/MtC was calculated based on cumulative discounted costs divided by cumulative carbon sequestered through 2020. The total discounted costs from 2007 to 2020 yield an NPV for this option of \$41 million.

## Part B: Urban Tree Planting

Two types of emissions reductions were calculated separately below for this goal: carbon sequestration in trees and CO<sub>2</sub> savings from reduced heating and cooling costs.

Carbon sequestration in urban trees was calculated at 0.0076 tC/tree/year (0.028 tCO<sub>2</sub>e/tree/year), based on the average for Montana in the USFS assessment of urban forests resources (Nowak et al., 2001). Using this value, total annual carbon sequestration from urban tree planting was calculated each year, including sequestration in trees planted that year and in prior years under the program.

A CO<sub>2</sub> savings factor for reduced heating and cooling needs was calculated for Montana using default factors published in USFS PSW-GTR-171. An average factor was calculated from defaults for the northern region of the United States, across three vintages of housing classes (pre-1950, 1950–1980, and post-1980). Separate factors for the shade effects of urban trees on cooling and heating demands and the wind effects on heating demands were calculated and then combined by adding them together for a single composite factor reflecting the net impacts. Default data for medium evergreen trees were used as a proxy for the types of trees planted. Table I-11 shows the default factors by vintage and effects categories as well as the final composite, which indicates that each tree planted will result in CO<sub>2</sub> savings of 0.1125 tCO<sub>2</sub>/tree/year.

**Table I-11. CO<sub>2</sub> savings factor for shading and wind reduction effects of urban trees**

Housing Vintage	Shade-Cooling	Shade-Heating	Wind-Heating	Net effect
pre-1950	0.122	-0.0227	0.1006	0.1999
1950–1980	0.0079	-0.0141	0.0658	0.0596
post-1980	0.0089	-0.0198	0.0889	0.078
Average (MtCO <sub>2</sub> e)	0.0463	-0.0189	0.0851	0.1125

MtCO<sub>2</sub>e = Metric tons carbon dioxide equivalents

Carbon sequestration and CO<sub>2</sub> savings were calculated by multiplying the factors above by the cumulative number of trees planted under the program each year, taking into account that carbon sequestration and energy savings continue every year after a tree is planted. Table I-12 shows the results of this analysis.

**Table I-12. Carbon benefits and program costs of urban tree planting**

Year	Number of Trees Planted	Cumulative Number of Trees in Program	Carbon Sequestered (MMtCO <sub>2</sub> e/year)	CO <sub>2</sub> Savings From Shading and Wind Effects (MMtCO <sub>2</sub> e/year)	Total Carbon Savings (MMtCO <sub>2</sub> e/year)
2008	3,250	3,250	0.0001	0.0004	0.0005
2009	3,250	6,500	0.0002	0.0007	0.0009
2010	3,250	9,750	0.0003	0.0011	0.0014
2011	3,250	13,000	0.0004	0.0015	0.0018
2012	3,250	16,250	0.0005	0.0018	0.0023
2013	3,250	19,500	0.0005	0.0022	0.0027
2014	3,250	22,750	0.0006	0.0026	0.0032
2015	3,250	26,000	0.0007	0.0029	0.0037
2016	3,250	29,250	0.0008	0.0033	0.0041
2017	3,250	32,500	0.0009	0.0037	0.0046
2018	3,250	35,750	0.0010	0.0040	0.0050
2019	3,250	39,000	0.0011	0.0044	0.0055
2020	3,250	42,250	0.0012	0.0048	0.0059

A cost of \$14.56/tree was estimated using a 40-year average for small, medium, and large conifer trees in northern mountain and prairie communities (McPherson et al.). Net cost savings were estimated at \$28.26/tree, considering energy conservation, storm water interception, clean air, and higher property values. Taken together, each tree yields a net cost savings of \$13.70. Using this value, total cost savings, cost-effectiveness (cost per ton of GHG reduced), and discounted costs (assuming a 5% interest rate) were calculated. Cost-effectiveness (cost per metric ton of carbon) improves through the duration of the time frame as the cumulative number of trees planted continues to accrue carbon sequestration and CO<sub>2</sub> savings without any additional costs. Undiscounted net annual costs are -\$44,525/year (negative indicates cost savings), i.e., -\$13.70/tree × 3,250 trees. The NPV for this option (sum of the discounted annual costs from 2008 to 2020) is estimated at -\$132,880. Overall cost-effectiveness is estimated at -\$3/MtCO<sub>2</sub>e, based on cumulative discounted costs divided by cumulative GHG savings.

**Key Assumptions:**

**(A) Restocking Goal:** The carbon sequestration rate in non-restocked forests is zero; forest types burned are proportional to dominant forest types; future annual rate of stand replacement fires of 20,000 acres/year.

**(B) Urban Trees Goal:** State-wide and regional carbon sequestration and CO<sub>2</sub> savings coefficients are representative of trees planted under the program. Costs and costs savings were based on 40-year averages for conifers.

**Key Uncertainties**

The number of acres that will burn in the future.

**Additional Benefits and Costs**

Increased wildlife habitat and ecosystem health.

Erosion control and water quality.

Increasing productive forestland more quickly.

Potential small business growth, e.g., contracting out restocking services.

**Feasibility Issues**

**Nursery Capacity:** Consider logistics and funding associated with the existing state nursery capacity and ability to respond to increased seedling demand.

**Availability of Seed Source Funding.**

**Status of Group Approval**

Completed.

**Level of Group Support**

Unanimous consent.

**Barriers to Consensus**

None.

## AFW-9. Improved Management and Restoration of Existing Stands

### Policy Description

This policy seeks to increase forest carbon stocks through changes in management practices on existing forestland. In contrast to the companion policy AFW-6, this policy is not restricted to working through existing forest health programs to promote new practices that increase tree density, enhance forest growth rates, alter rotation times, or decrease the chances of biomass loss from fires, pests, and disease. In addition, increasing the transfer of biomass to long-term storage in wood products can increase net carbon sequestration, provided a proper balance is maintained where enough biomass remains on site as residues serving as nutrient inputs to the forest. Practices may include management of rotation length, biomass density, biomass energy use, and sustainable use of wood products.

### Policy Design

**Goals:** Initiate programs to increase forest productivity by 20% on 700,000 acres of private and state forestlands by 2020.

**Timing:** Accelerate private forest landowner education programs by 2010. Implement forest improvement projects on 53,846 acres of state and private forestlands per year.

**Parties Involved:** Montana DNRC, Montana FWP, UM School of Forestry and Conservation, USFS, USDA NRCS; BLM, Bureau of Indian Affairs and tribal governments, county governments and other political subdivisions of the state, private nonprofit land trusts, nonprofit organizations.

**Other:** A 2001 study (Fiedler et al.)<sup>26</sup> estimated that 7.5 million acres of Montana's forestlands should be considered for treatment because they are in the moderate or high fire hazard condition in short-term fire-adapted ecosystems. Treating these stands would reduce fire hazard potential, improve forest health and diversity, and restore stand conditions. In 2005, more than 1.2 million acres of Montana's forestlands (all ownerships) were impacted by insects and diseases.

### Implementation Mechanisms

**Information and Education:** Work through the MSU Extension Forestry program and DNRC's Forest Stewardship Program to educate private forest landowners on the forest health and hazardous fuels mitigation benefits of implementing proper forest management and silvicultural practices. In turn, this will increase forest productivity and improve stand health. Use success stories from state trust lands to inform private landowners on the benefits of forest management.

**Technical Assistance:** Public education and outreach to landowners regarding existing federal and state programs. Continue DNRC Service forester assistance to nonindustrial private forest

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<sup>26</sup> Fiedler et al., A Strategic Assessment of Fire Hazard in Montana, Report to the Joint Fire Science Program [http://www.nifc.gov/joint\\_fire\\_sci/ummontanarpt.pdf](http://www.nifc.gov/joint_fire_sci/ummontanarpt.pdf)

landowners, targeting stewardship program graduates with current Stewardship Management Plans and private land management efforts such as The Blackfoot Challenge.

**Funding Mechanisms and/or Incentives:** Use NRCS and USFS state and private forestry cost-share programs to assist private forest landowners. Timber management focused on stagnant, overstocked, overage, or debilitated stands of trees would provide increased carbon sequestration. Incentives for this management would be ecologically improved and more productive forestlands and the sale of the harvested logs earnings enough to, at a minimum, pay for the cost of the work.

**Market-Based Incentives:** Support and engage in private sector markets for carbon sequestration that recognize the carbon benefits of forest management, urban forestry, and afforestation/reforestation (e.g., Chicago Climate Exchange). State participation further enhances state lead by example as an implementation mechanism.

**Enhancement of the Existing Programs:** Provide increased guidance and expertise to forestland owners to promote the implementation of proper forest management. DNRC currently has urban, nonindustrial, private forest landowner and forest health programs that provide information, education, technical assistance and, when available, financial assistance to landowners and urban forest managers.

These programs are predominately federally funded through USFS State and Private Forestry and Farm Bill funds. These programs are targeted for significant reduction in the President's 2008 budget proposal. Continuation of these federal programs is likely through state efforts in Washington, DC, and program enhancement through Montana legislative and fiscal support for these programs with a new focus on GHG reduction and carbon sequestration strategies.

**Hazard Identification:** Identify areas of high hazard within the wildland–urban interface and other high-risk areas (high fire hazard, severe overstocking, insect and disease attacks) to help target accelerated treatments for improving stand conditions, which will also result in improved stand productivity.

**Improve Inventory:** Collect stand data on 10% of forest stands on state trust lands within 10 years. Educate private nonindustrial landowners to do the same.

**Increase Forest Productivity:** On state trust lands, increase forest productivity on 12,000 to 15,000 acres per year through active forest management.

**Sustained Yield Calculation:** Consider statewide coarse filter sustained yield calculation across all land ownerships.

### **Related Policies/Programs in Place**

**Fire Risk and Forest Health Initiatives:** Current fire risk and forest health initiatives directed toward density reduction include the multiagency National Fire Plan and the Western Governors' Association 10-Year Comprehensive Strategy for Implementation of the National Fire Plan.

**Cost-Share Assistance Programs:** Cost-share assistance for fuels treatment on private lands is provided through the Community Protection Fuels Mitigation Grant Program and Western Wildland–Urban Interface Grant Program. Use NRCS and USDA State and Private Forestry cost-share programs to assist private forest landowners.

**DNRC Forest Management Goals and Objectives:** On state trust lands, the DNRC forest management objectives through the State Forest Land Management Plan and the current administrative rules are to move stands toward desired future conditions that are based on historical cover type distributions. More specific goals for state lands include thinning overstocked stands, reducing fire hazard, and managing for forest health and biodiversity.

**Department of Environmental Quality (MDEQ) Open Burning Program:** The Montana/Idaho State Airshed Group was formed in 1978 for minimizing or preventing the accumulation of smoke from prescribed fire to protect state and federal air quality standards and visibility in federal Class I areas. This is accomplished, in part, through MDEQ’s restricting open burning when atmospheric dispersion is not acceptable.

Montana has open burning regulations under Annotated Rules of Montana (ARM) 17.8.601 et. seq. It focuses on large open burners (those emitting more than 500 tons of carbon monoxide or 50 tons of other pollutants per calendar year).

Minor burners contribute emissions to airsheds but pay no fees. Minor open burners are not required by MDEQ to obtain an air quality open burning permit but must follow other best available control technology (BACT) procedures that include calling the smoke management hotline and obtaining a burning permit from their local forestry office.

**DNRC Forestry Assistance Programs:** Maintain and improve the health of Montana’s forests, forested watersheds, and the communities that depend on them. Tools include information and education, technical assistance, and financial assistance. Supporting programs could include the following.

- **Forest Stewardship:** Promote forest stewardship by helping nonindustrial forest landowners acquire knowledge about their forest resources and develop and implement a forest management plan for their property.
- **Urban and Community Forestry:** Provide Montana’s urban communities with assistance in establishing and maintaining healthy, productive, and financially beneficial urban forestry programs and urban forests.
- **Forest Pest Management:** Provide help with identifying and managing forest insects and diseases to nonindustrial forest landowners and others.
- **Conservation Seedling Nursery:** Produce and distribute seedlings for conservation plantings to private landowners, state, federal, and tribal landowners, and other conservation organizations.
- **Biomass Utilization:** Promote the use of forest biomass as an energy source for heating schools and other public facilities.

## Type(s) of GHG Reductions

Carbon stored in forest biomass and soils.

Carbon stored in harvested wood products.

## Estimated GHG Savings and Costs per MtCO<sub>2</sub>e

**Forest Carbon GHG Reduction Potential in 2010, 2020 (MMtCO<sub>2</sub>e):** 0.04, 0.2.

**Forest Carbon Cumulative GHG Reduction Potential (MMtCO<sub>2</sub>e, 2007–2020):** 1.2.

**Harvested Wood Carbon GHG Reduction Potential in 2010, 2020 (MMtCO<sub>2</sub>e):** 0.01, 0.01.

**Harvested Wood Cumulative GHG Reduction Potential (MMtCO<sub>2</sub>e, 2007–2020):** 0.14.

**Net Cost per MtCO<sub>2</sub>e:** \$119.

**Data Sources:** USFS Methods for Calculating Forest Ecosystem and Harvested Carbon with Standards Estimates for Forest Types of the US, General Technical Report NE-343 (also published as part of the US DOE Voluntary GHG Reporting Program), USFS FIA Program; T.F. Strong, 1997, “Harvesting Intensity Influences the Carbon Distribution in a Northern Hardwood Ecosystem,” USFS Research Paper NC-329.

### Quantification Methods:

This option aims to increase production in terms of harvest volumes (i.e., cubic feet per acre) by 20% on 700,000 acres of forestland in Montana through stand improvement treatments, including density reduction treatment such as pre-commercial thinning, commercial thinning, intermediate harvests, and selection harvests.

For the purposes of estimating the GHG benefits, it was assumed that three dominant forest types in Montana would be targeted for treatment. Specifically, this analysis assumes that 280,000 acres each of Douglas fir and ponderosa pine and 140,000 acres of lodgepole pine will be treated by 2020, for a total of 700,000 acres (Table I-13).

**Table I-13. Total acres targeted by the policy by 2020, by forest type**

Forest Type	Acres Treated by 2020
Douglas fir	280,000
Lodgepole pine	140,000
Ponderosa pine	280,000
Total	700,000

Stand improvement treatments are anticipated to impact carbon sequestration in two ways. First, they will enhance forest growth and carbon sequestration in forest biomass by 15%. Second, they will yield a 20% increase in harvest volumes, which will increase the amount of carbon stored in durable wood products. These impacts are quantified separately below in Table I-14. Two points: 1) net forest carbon sequestration is calculated as carbon sequestration due to growth minus carbon losses from removals (harvests) and 2) the amount of carbon stored in durable wood

products post-harvest is estimated using regional default coefficients for the use and disposal of wood products and corresponding carbon decay.

#### *Forest Carbon Sequestration*

Forest carbon sequestration rates under baseline conditions (no stand improvement treatments) were based on published carbon stocks (tC/acre in forest biomass) for Douglas fir, lodgepole pine, and ponderosa pine stands in the northern Rocky Mountain region (USFS GTR-343). Annual rates of carbon sequestration from forest growth (tons of carbon sequestered per year) were calculated by subtracting total carbon stocks in the forest biomass of 125-year-old stands from total carbon stocks in the forest biomass of new stands and dividing by 125. A long-term average was used to implicitly take into account the relatively fast rate of carbon accumulation in young stands and slower rates in older stands.

It was assumed that improved forest management would increase forest growth and carbon sequestration by 15%, based on expert opinion from Montana DNRC. USFS estimates of soil carbon stocks are constant over time. Therefore, this analysis assumes that no net carbon sequestration in forest soils occurs under the baseline or policy scenarios. Carbon sequestration rates under baseline and policy implementation are shown in Table I-14.

**Table I-14. Forest biomass carbon sequestration rates**

	Baseline	With Stand Improvement Treatments
	tons of carbon/acre/year	
Douglas fir	0.57	0.66
Lodgepole pine	0.39	0.45
Ponderosa pine	0.37	0.42

The analysis assumes that approximately 53,846 acres of forests are treated each year, starting in 2008 until 2020, when a total of 700,000 acres will have been treated. Table I-15 shows the cumulative acres treated per year by forest type as modeled in this analysis: starting in 2008, 21,538 acres each of Douglas fir and ponderosa pine and 10,769 acres of lodgepole pine are treated. This same amount of area is treated each year thereafter until the total number of acres treated in 2020 is 280,000 acres each of Douglas fir and ponderosa pine and 140,000 acres of lodgepole pine.

Annual carbon sequestration under policy implementation was calculated by multiplying the cumulative number of acres treated each year by the annual carbon sequestration rate for stand improvement treatments in Table I-14. This accounts for annual carbon sequestration benefits beginning in the first year that an area of forest is treated and continuing through the duration of the time frame of analysis. Annual removals were also calculated assuming a harvest rate of 1.3%/year, i.e., by multiplying the number of acres treated each year by 1.3%, which yields approximately 700 acres/year, and multiplying 700 acres/year by biomass carbon stocks in 65-year-old stands. The biomass carbon stocks were then multiplied by 39% to account for the amount of biomass removed during harvest. Strong (1997) estimates that a light harvest removes approximately 39% of forest carbon. The net change in growth (positive value) and removals (negative value) was calculated to yield a net annual carbon

flux (note: removals are shown as negative values to indicate that biomass is lost from the forest). Annual sequestration, removals, and net carbon flux under baseline conditions were calculated using the same area data and applying the baseline annual sequestration and 65-year-old carbon stocks values. The difference in net carbon flux between the policy and baseline cases is the total additional carbon sequestered within forests under this option. Results are shown in Table I-15.

**Table I-15. Acres targeted and estimated annual carbon sequestration (Seq.), removals, and net carbon flux under baseline and policy scenarios**

Year	Cumulative Acres Treated	Baseline			Policy Scenario			GHG Savings	
		Annual Seq. (A)	Annual Removals (B)	Net Carbon Flux (A+B)	Annual Seq. (D)	Annual Removals (E)	Net Carbon Flux (D+E)	Additional Seq. (D+E) – (A+B)	Additional Carbon Seq.
		tC/year							MMtCO <sub>2</sub> e
2008	53,846	24,441.8	-14,523.6	9,918.2	28,108.1	-15,249.8	12,858.3	2,940.1	0.011
2009	107,692	48,883.7	-14,523.6	34,360.1	56,216.2	-15,249.8	40,966.5	6,606.4	0.024
2010	161,538	73,325.5	-14,523.6	58,801.9	84,324.4	-15,249.8	69,074.6	10,272.7	0.038
2011	215,385	97,767.4	-14,523.6	83,243.8	112,432.5	-15,249.8	97,182.7	13,938.9	0.051
2012	269,231	122,209.2	-14,523.6	107,685.6	140,540.6	-15,249.8	125,290.8	17,605.2	0.065
2013	323,077	146,651.1	-14,523.6	132,127.5	168,648.7	-15,249.8	153,399.0	21,271.5	0.078
2014	376,923	171,092.9	-14,523.6	156,569.3	196,756.9	-15,249.8	181,507.1	24,937.8	0.091
2015	430,769	195,534.8	-14,523.6	181,011.2	224,865.0	-15,249.8	209,615.2	28,604.0	0.105
2016	484,615	219,976.6	-14,523.6	205,453.0	252,973.1	-15,249.8	237,723.3	32,270.3	0.118
2017	538,462	244,418.5	-14,523.6	229,894.9	281,081.2	-15,249.8	265,831.5	35,936.6	0.132
2018	592,308	268,860.3	-14,523.6	254,336.7	309,189.4	-15,249.8	293,939.6	39,602.9	0.145
2019	646,154	293,302.2	-14,523.6	278,778.6	337,297.5	-15,249.8	322,047.7	43,269.1	0.159
2020	700,000	317,744.0	-14,523.6	303,220.4	365,405.6	-15,249.8	350,155.8	46,935.4	0.172

## Carbon Sequestered in Harvested Wood Products

*Note: Metric units are used in this portion of the analysis because default coefficients in the USFS methodology for quantifying carbon sequestration in harvested wood products are in metric units.*

Stand improvement treatments are expected to enhance the amount of biomass available for harvest. The removal of biomass through harvesting transfers carbon stored in forest biomass to carbon stored in harvested wood products (HWP). Increased levels of production under this option will lead to more carbon transferred into HWP. The analysis below estimates the amount of additional carbon stored in HWP as a result of a 20% increase in productivity on treated forests.

Carbon sequestration in HWP was calculated following guidelines published by the USFS. Details on each step of the analysis can be found in the guidelines, following the methodology referred to as “land-based estimation.” In general, forest productivity is used as a starting point, and regional patterns in the disposition of carbon through various HWP pools are used to model carbon stock changes in HWP over time. The methodology calculates the transfer of carbon through four pools over time: wood in use (i.e., building materials, furniture), wood in landfills (i.e., products that were previously in use and have been discarded), wood burned for energy

capture, and wood that has decayed or burned without energy capture. The difference in the amount of carbon entering the “in use” and “landfill” pools at the beginning of a year and the amount remaining one year later equals total net annual carbon flux (i.e., sequestration) in harvested wood products (HWP).

Data from the USFS FIA Program in 2005 were used to estimate current levels of productivity for Douglas fir, lodgepole pine, and ponderosa pine in Montana. Average productivity was calculated separately for each forest type by dividing the total growing stock volume in timberlands by the total area of timberland in 2005. Average productivity in Douglas fir, lodgepole pine, and ponderosa pine stands in Montana was calculated to be 125, 162, and 72 cubic meters per hectare (m<sup>3</sup>/ha), respectively. Under implementation of this policy option, productivity is expected to increase by 20%; therefore, productivity on forests with improved forest management was calculated as a 20% increase over current levels (i.e., 150, 194, and 86 m<sup>3</sup>/ha on Douglas fir, lodgepole pine, and ponderosa pine, respectively).

**Table I-16. Background information on forest production by forest type (FIA, 2005)**

Species	Area of Timberlands (ha)	Growing Stock Volume (m <sup>3</sup> /year)	Baseline Average Production (m <sup>3</sup> /ha/year)	Average Production With Improved Forest Management (m <sup>3</sup> /ha/year)
Douglas fir	2,751,891	344,580,115	125.22	150.26
Lodgepole pine	1,439,387	232,661,602	161.64	193.97
Ponderosa Pine	1,189,055	85,327,889	71.76	86.11

There are several steps in the analysis where default coefficients for the northern Rocky Mountain region are applied to the starting point of average productivity. First, for each forest type, average productivity (m<sup>3</sup>/ha/year) is apportioned into classes of wood harvested (i.e., softwood sawlog, softwood pulpwood, hardwood sawlog, hardwood pulpwood) and the per-area carbon volumes of each class are calculated. Next, the quantity that is processed into primary wood products is calculated (factoring out carbon in logging residue, fuelwood, and waste), using the following ratios: ratio of industrial roundwood to growing stock volume removed as roundwood; ratio of carbon in bark to carbon in wood; fraction of growing stock volume removed as roundwood; and the ratio of fuelwood to growing stock volume removed as roundwood. The results are approximate per-area carbon stocks (tC/ha) in industrial roundwood, excluding bark and fuelwood. Carbon stocks in industrial roundwood were estimated for the baseline case using current levels of production as the starting point and for the policy scenario using levels of production under improved forest management as the starting point (Table I-17).

**Table I-17. Calculated carbon stocks in industrial roundwood**

Product Pool	Baseline (tC/ha)	Improved Forest Management (tC/ha)
Softwood saw log carbon in industrial roundwood	43.97	52.76
Softwood pulpwood carbon in industrial roundwood	48.97	58.76
Hardwood saw log carbon in industrial roundwood	0.08	0.10
Hardwood pulpwood carbon in industrial roundwood	0.49	0.59

The average disposition pattern of HWP over time in the northern Rocky Mountain region is provided by the USFS methodology. The disposition pattern is the flow of HPW between four pools over time: carbon in HWP in use, carbon in HWP in landfills, carbon emitted with energy capture, and carbon emitted without energy capture. Because there is not much hardwood in the northern Rocky Mountain region, as reflected in the relatively low carbon stocks for hardwood classes in Table I-17, the disposition patterns include only softwood categories of industrial roundwood. Thus, the remainder of the analysis includes only softwood.

Table I-18 shows the disposition pattern used in this analysis for a single harvest. According to Table I-18, in the year following harvest, 70% of the carbon in softwood goes into use, 21% is emitted with energy capture, 9% is emitted without energy capture, and none is placed in landfills. Over time the amount of carbon in use declines as it is transferred into the categories of carbon in landfills and carbon emitted to the atmosphere, such that by 100 years after harvest, approximately 11% of carbon remains in HWP in use, 26% is in landfills, and 63% has been emitted (note: carbon emissions from HWP are considered biogenic and are not counted as direct emissions).

The disposition over time of carbon stocks was modeled using the carbon stocks in Table I-17 (separately for the baseline and policy cases) and the disposition pattern in Table I-18 (same pattern used in baseline and policy case). This provides per-acre estimates of carbon stocks (tC/ha) remaining in each pool over time starting from a single harvest for both the baseline and policy scenarios. The total amount of carbon stocks and their disposition over time from a single harvest was calculated by multiplying the per-acre carbon stocks mentioned above by an average annual harvested area of 283 ha/year (i.e., 700 acres/year, which is 1.3% of the annual area of treated forest). The net impact of carbon storage in HWP as a result of regular annual harvests over the period of analysis was modeled for the baseline and policy cases. The incremental increase in carbon stocks was calculated as the difference between the two scenarios.

**Table I-18. Disposition pattern of carbon in HWP as a fraction of industrial roundwood for the northern Rocky Mountain region of the United States**

Year After Harvest	Fraction in Use	Fraction in Landfill	Fraction Emitted With Energy Capture	Fraction Emitted Without Energy Capture
0	0.704	0	0.209	0.087
1	0.664	0.019	0.223	0.094
2	0.628	0.036	0.235	0.101
3	0.595	0.051	0.247	0.107
4	0.567	0.065	0.256	0.112
5	0.541	0.077	0.265	0.118
6	0.517	0.088	0.273	0.122
7	0.495	0.098	0.28	0.127
8	0.474	0.107	0.287	0.131
9	0.455	0.116	0.294	0.135
10	0.438	0.124	0.3	0.139
15	0.373	0.152	0.32	0.154
20	0.33	0.171	0.333	0.165
100	0.112	0.255	0.373	0.26

The results of the analysis are summarized in Table I-19, which shows the amount of carbon stored in landfills and products in use each year above what would have happened in the baseline, spanning the time period 2008–2020. While the amount of additional carbon in landfills and in products from a given harvest decreases each year (as it is emitted through decay or energy capture), additional wood is harvested each year, adding new carbon stocks to the total HWP stream. Thus, for every year in the time series, the carbon stocks in the wood products pool are increasing. This analysis is carried out until 2020 and does not capture the continued disposition of carbon through the wood products pools in time.

The values in Table I-19 are incremental increases in HWP carbon stocks, with annual totals shown at the bottom. Carbon sequestration is calculated as the annual change in carbon stocks (subtracting stocks in year 2 from stocks in year 1). The net sequestration rate (last row) is sensitive to the year of analysis because the transfer of carbon between HWP pools is dynamic over time.

An alternative approach for estimating carbon stored in wood products is to estimate the amount of carbon remaining in products and landfills after 100 years and to apply that value to the year of harvest as an annual sequestration rate (GTR NE-343, 1605b technical guidelines). This approach essentially accounts for emissions occurring during 100 years after a harvest in the year of the harvest and assumes that the carbon remaining after 100 years is stored permanently. This approach was developed to simplify annual reporting of carbon stored in wood products and to account for the long-term dynamics of carbon flows in harvested wood products pools.

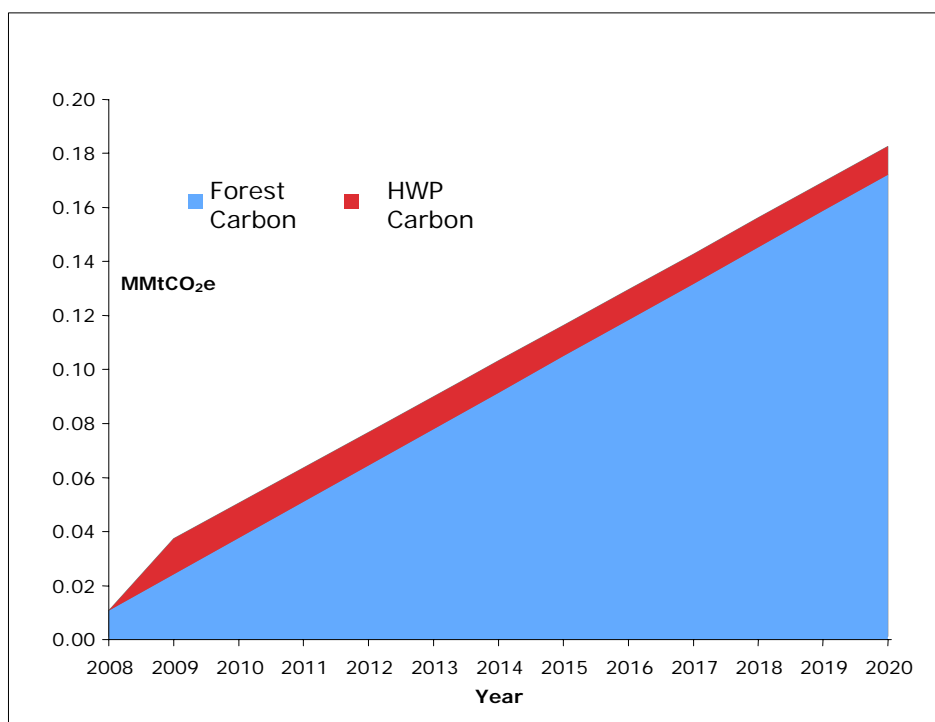
**Table I-19. Disposition of carbon in HWP over time, shown by tracking individual annual harvests from 2008 to 2020**

Year of Harvest	Carbon in Use or Landfill by the End of This Year												
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
2008	0.014	0.013	0.013	0.012	0.012	0.012	0.012	0.011	0.011	0.011	0.011	0.011	0.011
2009		0.014	0.013	0.013	0.012	0.012	0.012	0.012	0.011	0.011	0.011	0.011	0.011
2010			0.014	0.013	0.013	0.012	0.012	0.012	0.012	0.011	0.011	0.011	0.011
2011				0.014	0.013	0.013	0.012	0.012	0.012	0.012	0.011	0.011	0.011
2012					0.014	0.013	0.013	0.012	0.012	0.012	0.012	0.011	0.011
2013						0.014	0.013	0.013	0.012	0.012	0.012	0.012	0.011
2014							0.014	0.013	0.013	0.012	0.012	0.012	0.012
2015								0.014	0.013	0.013	0.012	0.012	0.012
2016									0.014	0.013	0.013	0.012	0.012
2017										0.014	0.013	0.013	0.012
2018											0.014	0.013	0.013
2019												0.014	0.013
2020													0.014
Total HWP Stocks (MMtCO <sub>2</sub> e)	0.014	0.027	0.040	0.052	0.064	0.076	0.088	0.099	0.111	0.122	0.132	0.143	0.154
Annual Change in Stocks (MMtCO <sub>2</sub> e/year)		0.013	0.013	0.012	0.012	0.012	0.012	0.011	0.011	0.011	0.011	0.011	0.011

For comparison with the analysis shown in Figure I-3, which tracks actual annual stocks and carbon sequestration during 2008–2020, the additional amount of carbon stored permanently above baseline levels 100 years after a single annual harvest is estimated to be 0.007 MMtCO<sub>2</sub>e. Using the 100-year method, the total amount of incremental carbon permanently stored from harvests during 2008–2020 is 0.09 MMtCO<sub>2</sub>e. This can be compared with the cumulative amount of carbon sequestration of 0.14 MMtCO<sub>2</sub>e during 2008–2020, as shown in Table I-19.

Total carbon savings, including forest carbon sequestration and carbon stored in HWP, are shown in Figure I-3. The majority of carbon sequestration occurs from increased forest growth. HWP carbon storage makes a small contribution to the overall benefit.

**Figure I-3. Total carbon savings from improved forest management**



HWP = harvested wood products; MMtCO<sub>2</sub>e = million metric tons CO<sub>2</sub> equivalents.

### Cost Analysis

The costs per acre to implement stand improvement treatments were assumed to be \$300/acre based on expert opinion of the TWG. Costs were multiplied by the number of acres treated annually, yielding an annual cost of \$16 million per year. Annual discounted costs were then estimated using a 5% interest rate. Cost-effectiveness (\$/tCO<sub>2</sub>e) was calculated by summing the annual discounted costs and dividing by cumulative GHG benefits (including forest and HWP carbon) during 2008–2020. (The annual accounting method for HWP was used in the analysis.) Cost-effectiveness is estimated at \$119/MtCO<sub>2</sub>e. The sum of annual discounted costs also provides an estimate of the NPV of this option of \$160 million. This analysis does not take into account the additional revenue generated from enhanced commercial value of treated stands, which would be a cost savings.<sup>27</sup>

### Key Assumptions:

Stand improvement treatments increase carbon sequestration by 15% and harvest volumes by 20%; harvest rates are 1.3%/year; regional patterns in the disposition of HWP represent conditions in Montana; stand improvement treatments result in instantaneous increases in growth and volumes harvested.

<sup>27</sup> This cost analysis does not factor in the commercial value from timber harvests associated with stand improvement treatments, which would increase the cost-effectiveness of implementing this option. Stand improvement treatments range from generating \$950/acre to costing \$325/acre, depending on the project and forest type. C.E. Fiedler, D.P. Wichman, and S.F. Arno. 1999. "Product and Economic Implications of Ecological Restoration," *Forest Products Journal*, 49(2):19–23.

## **Key Uncertainties**

Actual forest carbon sequestration will vary by site conditions, species classes, and specific management practices implemented. The analysis uses average values representative of the northern Rocky Mountain region for three common forest types and therefore does not take into account site-specific conditions.

Both HWP accounting approaches involve simplifying assumptions that in one case may overestimate carbon storage (annual accounting with instantaneous benefits) and in the other case may underestimate carbon storage (100-year accounting approach). The real benefits probably lie somewhere in between.

## **Additional Benefits and Costs**

Increased timber yields and revenues.

Reduced pest, disease, and fire risk.

Potential increased public exposure to smoke and increased trace GHG emissions.

Treating these stands would reduce fire hazard potential, improve forest health and diversity, and restore stand conditions.

## **Feasibility Issues**

- Loss of cost-share assistance or state budget cuts.
- Loss of forest industry.
- Litigation/appeals for state projects.
- Poor timber product markets will reduce financial incentives for management on non-industrial private lands.
- Loss of productive forestland.

## **Status of Group Approval**

Completed.

## **Level of Group Support**

Unanimous consent.

## **Barriers to Consensus**

None.

## AFW-10. Expanded Use of Wood Products for Building Materials

### Policy Description

This policy seeks to enhance the use and lifetime of durable wood products. Durable products made from wood prolong the length of time forest carbon is stored and not emitted to the atmosphere. Following their useful life (which could last for decades), wood products disposed of in landfills may store carbon for long periods under conditions that minimize decomposition. Additional GHG benefits can be achieved when methane gas is captured from landfills and used as an energy source (carbon originally stored in wood products becomes methane during decomposition). Increasing carbon stored in the wood products pool increases carbon sequestration from forests. This can be achieved through improvements in production efficiency, product substitution, expanded product lifetimes, and other practices. In addition, increasing the efficiency of the manufacturing life cycle for wood products enhances GHG benefits.

### Policy Design

**Goals:** The Climate Change Advisory Committee (CCAC) recommends that Montana adopt programs to expand the use of wood products by 5% over current baseline rates.

**Timing:** Increase usage by 2% by 2010 and 5% by 2020, above current trends.

**Parties Involved:** Building material suppliers, wood product industries, recycled building materials sellers, and others, UM School of Forestry and Conservation, all state agencies lead through example.

**Other:** Not applicable.

### Implementation Mechanisms

**State Adopted Policies:** The state should adopt policies that require wood products in the construction and maintenance of all state buildings when those products are feasible and relatively close in price (within 5%) to the alternative.

**Product Substitution:** Promote using wood products whenever and wherever feasible, instead of metal or synthetic building materials. Also promote replacing petroleum thinners and solvents with those derived from wood and tree sap/pitch (i.e., naval stores).

**Tax Incentives:** Give state tax incentives or low-cost loans for the development and production of new wood products and derivatives. Consider state tax credits for the use of wood products above existing normal levels in building energy efficient homes.

**Expanded Product Lifetimes:** Research, develop, and demonstrate new products that expand lifetimes through preservatives; these can also be derived from wood.

**New Products:** Develop new and expanded uses of wood, including filler for organic composting or bedding for livestock. Provide grants or support for research and development of

new products. The Montana University System would be an excellent vehicle for such research and development.

**Education/Outreach:** Develop information and education programs to promote product substitution (using wood products whenever and wherever feasible, instead of metal or synthetic building materials) and the benefits gained through carbon sequestration.

**Research and Development:** An inventory of needs and opportunities for durable wood product utilization in Montana should be conducted and should consider opportunities to increase the use of small-diameter wood in construction as well as use of wood instead of non-wood products. Ways to engage consumers in choosing to use wood should be considered as well as ways to promote the GHG benefits and local economic benefits.

MDEQ and utility companies offer programs that promote energy conservation and the use of renewable energy. Similar programs could be developed or expanded to promote the use of wood products (e.g., “good sense” homes.)

### **Related Policies/Programs in Place**

**State Hazard Reduction Regulations:** State forest hazard reduction laws and administrative rules require the reduction of timber slash during harvest projects. Although not required, the current laws and rules structure makes burning slash the most feasible method of reducing the hazard.

**Forest Service:** USFS has recently implemented a policy that requires contractors to haul and pile slash as landings to help facilitate removal of biomass during harvest operations.

**DNRC Logging Contracts:** Slash treatment requirements are currently part of all DNRC logging contracts.

**State Trust Land Forest Management Program:** DNRC has recently changed the timber bid sale process for state trust lands to encourage removal of residues for pulp and biomass.

### **Type(s) of GHG Reductions**

Displacement of life cycle emissions associated with production and use of industrial building materials (e.g., steel and concrete)

### **Estimated GHG Savings and Costs per MtCO<sub>2</sub>e**

**Estimated GHG Savings in 2010 and 2020:** Not quantified.

**Cost-Effectiveness:** Not quantified.

**Data Sources:** CCS reviewed available data sources including the Consortium for Research on Renewable Industrial Materials (CORRIM, Inc.) Phase I Research Report. This study provided the GHG reduction potential for substituting steel frames for wood frames in residential

structures, as well as physical characteristics in wood typically used in the West region.<sup>28</sup> Data were available through MDEQ on the number of residential structures per year that will be built in Montana, as well as population projections from the Montana GHG Inventory and Forecast. Data and GHG reduction estimates for industrial and commercial structures, as well as long-lived consumer products were not available at the time of this analysis. The available data sources did not allow for the development of methods to estimate GHG reductions from this option, since the envisioned implementation covers increased use of wood products in a broad array of building products and other materials. The available information captured only the potential increases in use in residential framing (a very small segment of the wood uses covered by this option). Hence, no estimates were made of GHG reductions or costs.

**Quantification Methods:** Not applicable; see Data Sources above.

**Key Assumptions:** Not applicable; see Data Sources above.

### **Key Uncertainties**

There is a lack of data and established methodologies to assess GHG reductions and costs for offsetting high-GHG-embedded building materials in the commercial and industrial sectors and in long-lived consumer products. For the residential sector, the estimated GHG reductions are also unclear whether significant increases can be made in offsetting high-embedded GHG products. Opportunities could exist in other building/finished wood products (e.g., siding, trim, flooring, cabinetry) in place of higher GHG-embedded materials.

Cost information for making substitutions of wood for high-GHG-embedded building materials was not identified for this analysis. The costs for implementing the programs described above for this option could not be estimated.

### **Additional Benefits and Costs**

Potential for greater in-state job creation and retention in forests products and building and finished wood products (e.g., trim, siding, cabinetry, furniture) sectors.

### **Feasibility Issues**

Cost-effectiveness of non-wood alternatives.

Availability of wood products to substitute for non-wood alternatives.

Quality and durability of wood versus the alternatives.

### **Status of Group Approval**

Completed.

### **Level of Group Support**

Unanimous consent.

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<sup>28</sup> J. Bowyer, D. Briggs, B. Lippke, J. Perez-Garcia, J. Wilson. Life Cycle Environmental Performance of Renewable Materials in the Context of Residential Building Construction. Prepared for CORRIM, Inc. [http://www.corrim.org/reports/2006/final\\_phase\\_1/index.htm](http://www.corrim.org/reports/2006/final_phase_1/index.htm)

## **Barriers to Consensus**

None.

## AFW-11. Programs to Promote Local Food and Fiber

### Policy Description

Programs that promote the production, distribution, and consumption of locally grown food and fiber products reduce transportation and manufacturing emissions by offsetting the consumption of products with higher embedded energy. Food and fiber products consumed in the United States can travel thousands of miles before reaching a grocery or clothing store in the form of a final product (on average a typical food product travels 1,500 miles and changes hands 33 times). Increasing the percentage of locally grown food and fiber consumed in Montana will significantly reduce fossil fuel use and its associated GHG emissions.

### Policy Design

**Goals:** 30% of food consumed in Montana is grown, harvested, and processed in Montana.

**Timing:** By 2010, 20%; by 2020, 30%.

**Parties Involved:** Promotion by MDOA (tracking of in-state product consumption), Farm Bureau, stock growers, Montana Cattlemen's Association, Grow Montana, AERO, National Center for Appropriate Technology (NCAT), sheep producers, wool growers, and grain growers.

**Other:** Montana-based food systems are a realistic vision. In 1950, 70% of the food Montanans ate was grown in Montana. Today, MDEQ estimates that it is 15%. Through the 1930s, food processing was Montana's number one employer. In the spring of 2003, the University of Montana-Missoula responded to student demand by launching the Farm to College Program, purchasing safflower oil, beef, bread, dairy products, and fruits and vegetables from Montana producers. In the past 2 years, the program bought more than \$500,000 from in-state sources. In the same period, the University's overall food costs—as a percentage of its food service budget—decreased.

### Implementation Mechanisms

**Buy Local Campaigns:** Encourage institutions that purchase large quantities of food to buy local. Some of the cost barriers to local purchasing were removed by the 2007 Legislature when Senate Bill 238 (SB 238) passed. This allows institutions to purchase Montana grown or processed food even when it costs a little more. Inform institutions at meetings and conferences about purchasing for state and local government and school districts.

**Made in Montana Food and Fiber Products:** Focus attention on “Made in Montana” food and fiber products through the MDOA program.

**Information and Education:** Include information on the benefits of buying local food and fiber as part of energy conservation programs that provide information through the popular Energize Montana Web site and frequently participate in fairs and home shows.

Working together to further define, develop, implement, and promote all local foods production, storage, processing, and consumption will require several strategies.

### Related Policies/Programs in Place

**Grow Montana Program:** Its goal is strengthening Montana's food and agricultural economy. Grow Montana (<http://growmontana.ncat.org/>) is a broad-based coalition whose common purpose is to promote community economic development policies that support sustainable Montana-owned food production, processing, and distribution and that improve all Montana's citizens access to Montana foods.

### Other Initiatives

**Mobile Meat Slaughter:** The 2005 Montana Legislature authorized the Montana Department of Livestock to inspect mobile meat slaughter units. By harvesting animals on-farm in an inspected mobile unit, farmers and ranchers can sell meat at any Montana retail, restaurant, or direct market. Bill text is available at <http://growmontana.ncat.org/docs/hb484final.doc>

**Local Food for Government Agencies:** The 2007 State Legislature changed procurement regulations to allow governmental bodies to purchase food from local sources even if the cost was higher as long as the higher bid was reasonable and capable of being paid from existing budgets with no additional appropriation needed (18-4-132 MCA).

**The UM Farm to College Program:** University Dining Services and four UM graduate students teamed up in the spring of 2003 to create the UM Farm to College Program, dedicated to buying more food locally and regionally to feed the campus community. See <http://ordway.umt.edu/SA/UDS/index.cfm/page/917>

**Farmers Markets:** Agriculture Marketing and Business Development Bureau, MDOA promotes local Farmers Markets. See <http://agr.mt.gov/business/farmersMkts07.pdf>

**Abundant Montana:** The AERO's Directory to Sustainably Grown Montana Food. More than 80 sustainable farms, ranches, and retailers are listed by region and by farm name, in the 5<sup>th</sup> edition of *Abundant Montana*, published in 2005. Products include fruits and vegetables, processed foods, meat products, and grains. The directory gives consumers who value sustainability and community the means to express their values through their food purchases while supporting the growers, processors, and retailers who share their values. See <http://www.aeromt.org/publications.php>.

### Type(s) of GHG Reductions

**CO<sub>2</sub>:** Reduction in CO<sub>2</sub> emissions due to a reduction in ton-miles required to bring out-of-state agriculture products to markets in Montana.

### Estimated GHG Savings and Costs per MtCO<sub>2</sub>e

**GHG Reduction Potential in 2010, 2020 (MMtCO<sub>2</sub>e):** 0.005, 0.02.

**Net Cost per MtCO<sub>2</sub>e:** \$5.

**Data Sources:** United States per capita food consumption was taken from the USDA Economic Research Service (ERS) Food Availability (Per Capita) Data System. Per capita consumption of each food type is shown in Table I-20. The average travel distance of imported food was taken from an Iowa study of food miles.<sup>29</sup>

**Table I-20. Per capita consumption, by food type**

<b>Food Category</b>	<b>U.S. Per Capita Consumption (lbs)</b>
Red meat	116
Chicken	86
Turkey	17
Fish	12
Eggs	33
All dairy	601
Fats and oils	87
Peanuts	7
Tree nuts	3
Coconut	1
Fresh fruit	122
Canned fruit	15
Dried fruit	2
Frozen fruit	5
Fruit juice	72
Fresh vegetables	184
Canned vegetables	108
Frozen vegetables	75
Legumes	6
Dehydrated vegetables	14
Potatoes for chips, shoestrings	16
Grains	192
Coffee, tea, cocoa	20
Spices	3
Beverages	116
<b>Total</b>	<b>1,911</b>

**Quantification Methods:** Total consumption of food was estimated for each year by multiplying projected population by the per capita consumption data referenced above. Table I-21 shows the estimated food consumption and the amount of food imported from out-of-state sources. The BAU percentage of out-of-state food was estimated by assuming that existing programs (UM Farm to College Program) targeting institutional food, which accounts for about 10% of Montana’s total consumption, achieves 30% consumption of in-state food by 2020. Hence, 90% of Montana food consumption has a 15% in-state content, while 10% of Montana consumption has a 30% in-state content.

<sup>29</sup> R. Pirog, “Checking the food odometer: Comparing food miles for local versus conventional produce sales to Iowa institutions.” Leopold Center for Sustainable Agriculture, 2003, [http://www.leopold.iastate.edu/pubs/staff/files/food\\_travel072103.pdf](http://www.leopold.iastate.edu/pubs/staff/files/food_travel072103.pdf)

**Table I-21. Estimated food consumption and amount of food imported**

Year	Montana Food Consumption (tons)	% Locally Purchased Food	BAU % Locally Purchased Food	Food From Out-of-State (tons)	BAU Food From Out-of-State (tons)
2007	905,345	15%	15%	769,543	769,543
2008	912,073	17%	15%	760,061	774,209
2009	918,801	18%	15%	750,354	778,861
2010	925,529	20%	15%	740,423	783,496
2011	930,702	21%	15%	735,255	786,801
2012	935,875	22%	16%	729,983	790,095
2013	941,048	23%	16%	724,607	793,376
2014	946,221	24%	16%	719,128	796,645
2015	951,394	25%	16%	713,546	799,903
2016	956,567	26%	16%	707,860	803,149
2017	961,740	27%	16%	702,070	806,382
2018	966,913	28%	16%	696,177	809,604
2019	972,086	29%	16%	690,181	812,814
2020	977,259	30%	17%	684,081	816,011

The reduction of food miles was estimated by taking the difference between the BAU food from out-of-state and the food from out-of-state under this policy and multiplying by average difference in miles traveled by in-state and out-of-state food. The average miles by out-of-state food was assumed to be 1,500 miles plus an additional 25% to account for trucks returning to their points of origin empty (1,825 miles). Since Montana is a relatively large and sparsely populated state, in-state food was assumed to travel 200 miles plus 25% (250 miles), for a difference of 1,575 miles between in-state and out-of-state food. The food transport emission factor (0.162 lb CO<sub>2</sub>/ton-mile) was estimated by assuming 23-ton payload trucks, 6 truck-miles/gal diesel, and 22.4 lb CO<sub>2</sub>/gal diesel.

### Cost

The development of a local food advocacy program is expected to help reach the 2020 target that requires 30% of food consumed in Montana to be grown, harvested, and processed in-state. The cost of such a program is expected to equal the cost of one half of a full-time senior-level program development employee. The full-time equivalent (FTE) of such an employee is assumed to be \$75k per year. The cost of the implementation program is therefore \$37,500 in the first year, increasing by 5% per year through the end of the target period. The resulting NPV (in \$2007) is \$0.5 million, and the levelized cost-effectiveness is \$5/MtCO<sub>2</sub>e.

### Key Assumptions:

The assumption that 25% of out-of-state trucks return from their delivery point empty is a standard assumption. Although the low density of food processors and markets may increase the probability that these trucks return empty, there is an absence of sufficient data that would support amending this assumption.

It is assumed that all private costs associated with the implementation of this option will be recovered through market mechanisms. Therefore, no subsidies for locally produced food

products are necessary to include in the cost analysis of this option. These would include the costs associated with additional production, processing, storage, and distribution infrastructure. The only costs that have been captured are the modest costs to the state for additional staffing to implement programs to achieve the policy goals.

### **Key Uncertainties**

The largest source of uncertainty is whether the region can supply the variety of agricultural products needed to supply 30% of Montana consumption. Significant work will be needed to identify and promote products that can be regionally produced to meet the goals of this policy. Another significant uncertainty is whether the programs needed to achieve the policy goal can be implemented without incentives for enhancing the state's production, processing, storage, and distribution infrastructure.

### **Additional Benefits and Costs**

An increase in Montana jobs for farmers, food processors, and associated industries.

### **Feasibility Issues**

See key uncertainties above.

### **Status of Group Approval**

Completed.

### **Level of Group Support**

Unanimous consent.

### **Barriers to Consensus**

None.

## AFW-12. Enhanced Solid Waste Recovery and Recycling

### Policy Description

Programs are needed to increase the quantity of materials recovered for recycling with specific attention given to materials with the greatest ability to reduce energy consumption during the manufacturing process and to materials that may be used as a fuel source (e.g., clean wood waste). Reducing the quantity of materials being landfilled reduces future landfill methane emissions potential, while recycling reduces emissions associated with the manufacturing of products from raw materials.

### Policy Design

**Goals:** Increase Montana solid waste recycling rates to 17% by 2008, 22% by 2011, 25% by 2015, and 28% by 2020 using a variety of methods, including source reduction, reuse, recycling, and composting.

**Timing:** See above.

**Parties Involved:** MDEQ, Montana Association of Counties (MACo), MSU Extension, local governments, other landfill operators (private), and recycling firms.

**Other:** Based on MDEQ estimates, the current recycling rate overall was 14.3% in 2005. Total diversion was 18.7%, which includes composted material.<sup>30</sup>

MDEQ is responsible for implementing the Integrated Solid Waste Management Act (75-10-803 MCA). Under this act, MDEQ convenes a group of interested parties to review and recommend goals to increase recycling in the state and reduce waste and to develop an Integrated Waste Management Plan. Recommendations for policy implementation come largely from this Plan. Recycling and composting goals are set in the Integrated Solid Waste Management Act. They are 17% by 2008, 19% by 2011, and 22% by 2015. This policy option sets goals higher than the Integrated Waste Management Plan and will require additional effort.

### Implementation Mechanisms

**Educational Outreach:** Educate consumers and businesses on the benefits of recycling and local opportunities to recycle. Because the opportunity to recycle specific goods changes frequently, and because people move in and out of communities, it is necessary to provide a consistent educational effort.

**Develop Local Markets for Recycled Materials:** Recycling through traditional markets in major metropolitan areas is difficult because of the high cost of transportation from Montana communities to these markets. The cost of transportation is more than the value of the materials shipped except for metals, cardboard, and some paper. Local uses for materials need to be developed and incentives need to be provided to help develop these markets.

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<sup>30</sup> MDEQ 2005 Recycling Summary, [http://deq.mt.gov/Recycle/2005Recy\\_Summary\\_01-11.htm](http://deq.mt.gov/Recycle/2005Recy_Summary_01-11.htm)

**Encourage Inter-County Cooperation Using the Headwaters Recycling Model:** Headwaters Recycling is a group of counties in southwest Montana that have joined together with Yellowstone National Park to collect recycled materials from rural areas. While no county could provide the services by itself, Headwaters provides equipment and staff that are shared by all. This model needs to be replicated in eastern and northwestern Montana.

**Increase Recycling of Construction and Demolition Wastes:** The amount of construction and demolition waste entering landfills in the high-growth areas of western Montana may be as much as 30% of the total waste. This waste, particularly wood products, needs to be diverted from landfills. Wood can be diverted for composting and possibly biomass energy production. Metals and cardboard can be recycled.

**Encourage Integration of Waste-to-Energy in Sewage Treatment Plant Upgrades:** MDEQ has provided limited technical assistance to local governments exploring the option of using biogas to generate electricity. MDEQ should encourage this option and set clear requirements for permitting these upgrades that will allow for complete and timely review.

**Encourage the Composting of Biosolids Over Landfilling:** MDEQ has knowledge of how biosolids are being managed and where they end up from their review of permits for sewage treatment plants and septic system pumper operations. MDEQ should discourage biosolids from being disposed of in landfills and encourage the composting of biosolids.

**Encourage Montana Landfills To Participate in the EPA Methane Outreach Program:** At least four Montana landfills are large enough to produce enough methane to have the potential for use. MDEQ should encourage the use of this methane when landfills come in for permitting and present plans for how to control the environmental quality at the landfill.

**Promote “Cradle to Cradle Responsibility” That Requires Manufacturers To Take Products They Produce Back for Recycling at the End of Their Useful Life:** Through the MDEQ, Montana is the first rural state that is working with EPA on initiatives to get manufacturers to take back electronics they produced. Montana does not have enough population or market share to drive a program that requires manufacturers to take back products. However, by joining together with other states and working for national policies and legislation, Montana can influence manufacturers to take back their products. MDEQ should continue to work with national and regional efforts and support policies and legislation for “Cradle to Cradle Responsibility.”

**Lead by Example:** Montana state government needs to lead by example by increasing its recycling rate and by implementing policies that will result in less waste that needs to be recycled. MDEQ and the Department of Administration have responsibility under the Integrated Waste Management Act (75-10-805 MCA) to develop a waste reduction program for state government. This authority needs to be used to establish aggressive recycling and source reduction program for all state agencies.

## **Related Policies/Programs in Place**

**Montana Integrated Waste Management Act and Plan:** The Montana Integrated Waste Management Act sets recycling targets of 17% by 1998, 19% by 2011, and 22% by 2015 and

requires that a plan be put in place to achieve these targets. MDEQ must develop the plan in consultation with interested local governments, recycling businesses, solid waste businesses, and environmental organizations. The goals were updated by the 2005 Legislature and the Plan was updated in 2006. It will be updated again in 2011.

**State Government Waste Reduction and Recycling Program:** This program was established as part of the Integrated Waste Management Act. It requires MDEQ to work with state agencies to reduce waste and increase recycling.

**State Government Procurement of Recycled Supplies and Materials:** Part of the Montana Integrated Waste Management Act (75-10-806 MCA) requires that the Department of Administration develop specifications for purchasing materials and supplies that have recycled content. The Department of Administration belongs to the Responsible Purchasing Network.

**Licensing of Recycling and Composting Businesses:** MDEQ provides licenses for recycling and composting businesses at no cost. Licenses allow MDEQ to track individual events and ongoing business and to ensure that environmental laws are followed.

**Tax Credit for the Purchase of Recycling Equipment:** An individual, corporation, partnership, or small business corporation may receive a tax credit for investments in depreciable property used primarily to collect or process reclaimable material or to manufacture a product from reclaimed material according to the following schedule:

- 25% of the cost of the property on the first \$250,000 invested,
- 15% of the cost of the property on the next \$250,000 invested, and
- 5% of the cost of the property on the next \$500,000 invested.

This credit through 15-32-601 MCA (terminates December 31, 2011).

**Purchase of Recycled Materials Deduction:** Taxpayers who purchase recycled material as a business-related expense can deduct 10% of the expense of these products from federal adjusted gross income in arriving at Montana adjusted gross income (15-32-609 MCA terminates December 31, 2011).

**Deduction for Purchase of Montana Produced Organic Fertilizer:** Taxpayers may deduct expenditures for organic fertilizer, such as compost, that is produced in Montana and used in Montana (15-32-303 MCA).

**Credit Against Air Permitting Fees for Certain Uses of Post-Consumer Glass:** A person with beneficial interest in a business may receive a credit against the fees imposed in 75-2-220 (Air Quality) for using post-consumer glass in recycled material if qualified under HB 499 Section 3.

## **Type(s) of GHG Reductions**

**CO<sub>2</sub>:** Upstream energy use reductions—The energy and GHG intensity of manufacturing a product is generally less using recycled feedstocks than from using virgin feedstocks.

**Methane:** Diverting organic wastes from landfills will result in a decrease in methane gas releases from landfills.

### Estimated GHG Savings and Costs per MtCO<sub>2</sub>e

**Estimated GHG Savings in 2010 and 2020:** 0.05, 0.55.

**Cost-effectiveness:** \$17/MtCO<sub>2</sub>e.

**Data Sources:** These include information from MDEQ's 2005 Recycling Summary cited above and EPA's WASTE Reduction Model (WArm). 2005 MDEQ recycling data are shown in Table I-22.<sup>31</sup>

**Table I-22. MDEQ recycling data, in tons**

Recycled Material	2005 Tons
Aluminum cans	549
Steel cans	285
Glass	262
HDPE (plastic)	97
PET (plastic)	170
Corrugated cardboard	38,870
Magazines/third-class mail	1,056
Newspaper	10,938
Office paper	1,326
Phone books	8,265
Mixed paper	135
Mixed metals	99,798
Mixed recyclables	103,979
Computers/electronics	1
<b>Total</b>	<b>257,545</b>

In addition, there was a total of 64,524 tons of material composted.

**Quantification Methods:** GHG Reductions.

### Non-organics Recycling

WArm was used to estimate GHG reductions achieved via recycling.<sup>32</sup> The wastes in Table I-22 were aggregated into the applicable WArm material categories (initial estimates based on mixed recyclables): mixed paper waste (fibers in Table I-22), mixed metals (scrap metals in Table I-22), and mixed recyclables (containers and miscellaneous in Table I-22). A baseline estimate of waste recycling and associated GHG reductions for 2005 (representing a 14% MSW diversion rate) was established by inputting the diverted quantities for each waste material.

<sup>31</sup> L. Moore, MDEQ, personal communication with S. Roe, CCS, August 2007.

<sup>32</sup> The WArm model and associated documentation can be downloaded from <http://yosemite.epa.gov/oar/globalwarming.nsf/WARM?OpenForm>. Note that CCS excluded organic materials diverted for composting from the recycled amounts in this analysis (they are handled separately).

The incremental benefit for 2010 and 2020 was then determined by inputting the additional quantities of waste that would be recycled in each year (21% in 2010 and 28% in 2020). These additional quantities of recycled materials excluded organic materials (addressed below). CCS assumed that the fractions of materials diverted remained the same as in 2005 (initial estimates based on mixed recyclables): mixed paper (0.56); mixed metals (0.23); and mixed recyclables (0.21). CCS also determined the waste generation in each future year using the same 0.6%/year population growth as in the GHG Inventory and Forecast. Finally, the volume of organic material composted is assumed to rise at the same rate as recycled materials. Table I-23 shows the resulting waste recycling amounts and rates in each year.

**Table I-23. Waste diversion rates**

	Year			
	2005	2010	2015	2020
MSW landfilled	1,184,198	1,220,153	1,257,199	1,295,371
MSW recycled (minus organics)	257,545	307,823	399,196	478,930
Organics composted	64,524	69,142	83,572	102,343
Recycle rate (excludes organics)	17.1%	17.6%	19.9%	22.6%
Diversion rate (includes organics)	21.4%	22.0%	24.9%	28.3%

For the incremental tons recycled, WArm provided the results shown in Table I-24.

**Table I-24. WArm results, in tons**

Scenario	MtCO <sub>2</sub> e
2005 baseline recycling WArm GHG reduction	1,142,012
2010 incremental WArm GHG reduction	1,187,692
2020 incremental WArm GHG reduction	1,676,208

Hence, in 2010, the incremental GHG benefit for additional recycling is 45,680 MtCO<sub>2</sub>e/year. In 2020, the incremental benefit is 534,196 MtCO<sub>2</sub>e/year.

## Composting of Organic Material

By composting organic material, the CH<sub>4</sub> emissions that would have been generated via anaerobic decomposition in a landfill are avoided. Landfill methane avoided for the baseline (2005) organics material diversion was estimated using an estimate of the degradable organic carbon (DOC) content from the United Nations Framework Convention on Climate Change (UNFCC).<sup>33</sup>

For this assessment, landfill gas (LFG) generated at the applicable landfills in Montana is assumed to be collected and controlled. The EPA default methane collection efficiency of 75% is applied. Also, the default assumption of 10% oxidation of CH<sub>4</sub> as it diffuses through the landfill

<sup>33</sup> UNFCC, CDM–Executive Board, “Approved baseline and monitoring methodology AM0039,” September 29, 2006. The average DOC content for lawn and garden, food, and wood/straw waste is 21%. Default CH<sub>4</sub> content of landfill gas is 50%. 16/12 is the ratio of molecular weights of carbon and methane. 21 is the global warming potential of methane.

soil cover is applied. The 2010 baseline landfill methane avoided is calculated as follows (see footnote for additional details):

$$\begin{aligned}\text{Baseline 2010 CH}_4 &= (64,524 \text{ ton organics}) \times (0.21) \times (0.50) \times (0.907 \text{ Mt/ton} \times (16/12) \times 21 \times (1 - 0.75) \times \\ &\quad (1 - 0.10) \\ &= 39,888 \text{ MtCO}_2\text{e}\end{aligned}$$

The same method was used to calculate the methane avoided for the higher levels of organics to be recycled in 2010 (69,142) and in 2020 (102,343), as shown in Table I-23. The incremental benefit of increased organic material composting was then estimated as the difference between the baseline recycling level and the policy recycling levels in each year. For 2010, the incremental benefit is 1,595 MtCO<sub>2</sub>e and 17,949 MtCO<sub>2</sub>e in 2020.

Because GHG emissions also occur as a result of composting, these emissions need to be factored in to obtain a net GHG benefit for organics recycling. CCS used an average CH<sub>4</sub> emission factor of 1.12 lb/ton material from tests conducted by the South Coast Air Quality Management District in California.<sup>34</sup> CH<sub>4</sub> emissions from incremental composting are estimated to be 28 MtCO<sub>2</sub>e in 2010 and 339 MtCO<sub>2</sub>e in 2020. Nitrous oxide emissions were estimated from tests done on composting of cattle manure<sup>35</sup> (no data on MSW organic materials were identified). The average N<sub>2</sub>O emission factor was 0.94 lb/ton of manure. Applying this emission factor to the incremental organic materials composted in 2010 and 2020 yielded 352 MtCO<sub>2</sub>e and 4,198 MtCO<sub>2</sub>e, respectively. The net GHG benefits for the incremental organics composting are shown in Table I-25.

**Table I-25. Net estimated GHG benefits for organic composting**

Estimate	2010 MtCO <sub>2</sub> e	2020 MtCO <sub>2</sub> e
Landfill methane avoided	1,595	17,949
Composting methane	28	339
Composting nitrous oxide	352	4,198
<b>Net GHG benefit</b>	<b>1,215</b>	<b>13,412</b>

Therefore, the overall emission reductions for the policy option are 46,895 MtCO<sub>2</sub>e in 2010 and 547,608 MtCO<sub>2</sub>e in 2020.

## Costs

*Non-organics recycling.* CCS assumed that the policy would be applied to households in the three Montana counties with the highest population density: Yellowstone County (52,084 households, 49.09 people/mi<sup>2</sup>), Silver Bow County (14,432 households, 48.18 people/mi<sup>2</sup>), and Missoula County (38,439 households, 36.88 people/mi<sup>2</sup>).<sup>36,37</sup> Single-stream recycling service

<sup>34</sup> Average of three facilities conducting composting of a variety of organic materials—digested biosolids, manure, wood waste, rice hulls, and green waste. Documented in Roe et al., 2004, *Estimating Ammonia Emissions from Anthropogenic Nonagricultural Sources*, Final Report, prepared for US EPA, Emission Inventory Improvement Program, April 2004.

<sup>35</sup> X. Hao, C. Chang, F.J. Larney, and G.R. Travis, “Greenhouse Gas Emissions During Cattle Feedlot Manure Composting,” *Journal of Environmental Quality*, 30:376–386, 2001.

<sup>36</sup> Montana County Population; Population Density 2000. Accessed on June 20, 2007 at [http://ceic.commerce.state.mt.us/graphics/Data\\_Maps/Densitymap.pdf](http://ceic.commerce.state.mt.us/graphics/Data_Maps/Densitymap.pdf)

would cost \$3.50 per pick-up with pick-ups occurring every 2 weeks. Further, it is assumed that households would fill a 96-gallon container with mixed recyclables, which result in an annual average cost per household of \$91. The total annual cost for all households would be \$9.6 million.

There is also societal cost savings associated with this option in that landfill tipping fees are avoided for the waste that is diverted. Tipping fees in Montana are \$25.38 per ton. Using an EPA estimate of waste density (0.05 ton/yd<sup>3</sup>), the volume of the recycle container, the number of pick-ups per year, and the number of households, the maximum amount of total waste to be diverted was estimated to be 754,809 tons/year, assuming that all collection containers are full. Using the mid-point of the range in tipping fees and 25% of the maximum waste avoided, the avoided landfill cost is \$4.8 million/year. The net cost for the non-organics recycling is \$5.1 million/year. Using the GHG reduction estimates derived above, the cost-effectiveness in 2020 is \$7.86/MtCO<sub>2</sub>e.

### Organics Composting

The cost of organics composting is based on the total quantity of organic material composted under the BAU scenario, less the total quantity of organics composted after the adoption of the targets imposed by this action. The per-ton cost was largely derived from capital and operation and maintenance (O&M) cost estimates provided via personal communication.<sup>38</sup> The cost estimates used in this analysis are provided in Table I-26.

**Table I-26. Cost estimates for organics composting**

Annual Volume (tons)	Capital Cost (\$ in thousands)	Operating Cost (\$/ton)
<1,500	75	25
1,500–10,000	200	50
10,000–30,000	2,000	40
30,000–60,000+	8,000	30

The capital costs were annualized using the cost recovery factor method. This method takes the product of the total annual capital cost and a factor that includes assumptions of a 15-year project life and a 5% interest rate. The annualized capital cost is added to the annual O&M cost and the tipping fee is subtracted to determine the total annualized composting costs. This value does not take into account any revenue raised from the sale of compost.

As reported above, the current average tipping fee in Montana is \$25 per ton. Therefore, since the total annual cost-per-ton is greater than the tipping fee, composting projects are expected to have a net cost. The NPV of costs related to composting—assuming a constant \$25 tipping fee—is \$4.82 million.

<sup>37</sup> U.S. Census Bureau; Montana State and County Quickfacts. Accessed on June 20, 2007 at <http://quickfacts.census.gov/qfd/states/30000.html>

<sup>38</sup> P. Calabrese, Cassella Waste Management, personal communication with S. Roe, CCS, June 5, 2007. Transmitted via e-mail to B. Strode by S. Roe.

**Key Assumptions:**

Assumptions used in the EPA WARM modeling include the use of the “current mix” of recycled and virgin material inputs to production (i.e., new products are not produced with 100% virgin materials); LFG is flared; 75% collection efficiency for LFG; distance to the landfill and recycling facilities (50 miles). Another key assumption is how representative the N<sub>2</sub>O composting emission factor is in representing emissions from composting MSW organic materials.

**Key Uncertainties**

See Key Assumptions above.

**Additional Benefits and Costs**

Lower emissions of LFG for the decomposable waste that would be landfilled without this policy option. In addition to methane, LFG contains other air pollutants, such as volatile organic compounds and toxic air pollutants.

**Feasibility Issues**

Challenges for implementing this option include a current lack of post-consumer recycling markets (much of the waste currently recycled is sent out of state). Significant effort will be needed to identify new recycling opportunities in Montana. For post-consumer mixed organic waste diversion, increasing the amount and the range of wastes composted might not be feasible at small-scale facilities due to equipment requirements, higher capital costs, and lack of markets for compost residue (whereas the end product from organic composting may be sold as fertilizer).

Co-operating a landfill with an organic composting operation could necessitate additional equipment for odor control. The capital costs of odor control equipment vary, depending on the size of the operation and the available buffer zone between the landfill sites and surrounding communities. For some wastes—particularly heavy nitrogenous or wet wastes—bulking agents are necessary to properly manage the composting operation. These bulking agents are major factors in operations and maintenance costs of composting facilities.

**Status of Group Approval**

Completed.

**Level of Group Support**

Unanimous consent.

**Barriers to Consensus**

None.